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SECTION 2

Document Information			
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Title	**FEASIBILITY STUDY FOR THE 200-TW-1 SCAVENGED WASTE GROUP & THE 200-TW-2 TANK WASTE GROUP & THE 200-PW-5 FISSION-PRODUCT RICH WASTE GROUP OU**		
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6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 5.0 for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites included in this FS. The waste sites evaluated in this FS have characteristics (e.g., size, waste type, extent of contamination, location) that influence the analysis of the CERCLA evaluation criteria. Analogous waste sites were assigned to representative sites in Chapter 2.0. These assignments are based on the physical framework and expected distribution of contamination using available information and process knowledge. The assignments in Chapter 2.0 also include the relationship between the representative site and the analogous sites. For example, an analogous site that is very similar to the representative site is assumed to have risks and contaminant distribution similar to those of the representative site. Therefore, the detailed analysis for the representative site is assumed to be appropriate for the analogous site. If the analogous site is assumed to be either less contaminated (and therefore less risky) or more contaminated (and therefore more risky) than the representative site, then the analogous site is evaluated considering site-specific differences from the representative site. The detailed analysis of alternatives for the representative site also will include an evaluation of these site-specific differences and their influence on alternative selection for the analogous sites.

The detailed analysis is presented by alternative. The evaluation of the representative sites is included within the discussion of each alternative. Tables 6-1 through 6-4 provide a summary of the detailed analyses for the representative sites and all analogous sites.

Figure 6-1 guides the application of alternatives to the representative sites using overall protection of human health and the environment as its decision basis. The starting point of this tool is an evaluation of risk for each individual representative site based on contaminants of concern, their mobility in the Hanford environment, and their location in the vadose zone with respect to ground surface.

The identified alternatives reflect the nature of the contaminants at each site and the assumed land use. Currently, the land use for the 200 Areas is industrial in nature, associated with the management of waste. This land use can be reasonably predicated to be the same for the next 50 yr, given DOE's current commitment to vitrify waste in the tank farms. Industrial use is assumed after that period. However, loss of institutional control also is assumed after 150 yr for evaluation purposes. The COCs are persistent beyond 150 yr at all the representative sites. After 150 yr, the risk to intruders becomes the controlling risk for the waste sites because of the high levels of Cs-137 and Sr-90 associated with the representative sites. Risks to intruders were calculated for the representative sites and the analogous waste sites, with characterization data, in Appendix E.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The EPA has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (Interim Final)*, OSWER 9355.3-01, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or that do not comply with ARARs (or justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FS.

The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria on which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria. The criterion of state acceptance will be addressed in the Proposed Plan (DOE/RL-2004-10, *Proposed Plan for the 200-TW-1 Scavenged Waste Group, 200-TW-2 Tank Waste Group, and 200-PW-5 Fission-Product-Rich Waste Group Operable Units*), a document prepared by the Tri-Parties. The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

In addition to the CERCLA criteria, NEPA values have been incorporated into this document. Assessment of these considerations is important for the integration of NEPA values into CERCLA documents, as called for by both *Secretarial Policy on National Environmental Policy Act* (DOE 1994) and DOE O 451.1A, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This first criterion is a threshold requirement and is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion and the criteria for compliance with ARARs, long-term effectiveness and permanence and short-term effectiveness, overlap (EPA/540/G-89/004). This feasibility study used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} for human health as the indication of protectiveness. Alternatives were measured against this standard to determine if the alternative meets this criterion. Protection of groundwater was measured against groundwater protection standards derived from the MCLs identified in 40 CFR 141 and on fate and transport modeling, reported in DOE/RL-2002-42. The ecological compliance was evaluated using screening levels in WAC 173-340-900, Table 749-3, and DOE/STD-1153-2002.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any Federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain on site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/2-88/002, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites*; EPA/540/G-89/004). Potential Federal and state chemical-, location-, and action-specific ARARs associated with remediation of the 200-TW-1, 200-TW-2, and 200-PW-5 OUs are presented in Appendix B, and each alternative is assessed for compliance against these ARARs. When an ARAR is not met, the basis for justifying a waiver must be presented. Several of these ARARs address the protection, restoration, or enhancement of fish and wildlife habitat and other natural, cultural, and historical resources.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after RAOs are met. The primary focus of this evaluation is the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative.

- Magnitude of residual risk to human and ecological receptors. - This factor assesses the residual risk from untreated waste or treatment residue after remedial activities are completed. The characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls. - This factor assesses the adequacy and suitability of controls used to manage treatment residues or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residues, and it includes an assessment of the potential need to replace the technical components of the alternative.

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including fish and wildlife habitat and cultural resources, where appropriate. Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remedial alternative reduces the toxicity, mobility, or volume of a hazardous substance through treatment. Significant overall reduction can be achieved by destroying toxic contaminants or by reducing total mass, contaminant mobility, or total volume of contaminated media.

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are used in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the speed with which an alternative achieves protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves any risk resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from off-gas emissions
- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated

- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. The greater the exposure time, the greater the risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and maintain exposures ALARA.

Short-term environmental impacts are related primarily to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species (e.g., bald eagles) because of increased human activity in the area.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials.

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies (e.g., failures)
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)
- Availability of services and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance costs, and monitoring costs. The cost evaluation also includes monitoring of any restoration or mitigation measures for natural, cultural, and historical resources.

The cost estimates for the purposes of this study are presented in either 2003 constant dollars or present-value terms. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

This criterion evaluates the technical and administrative issues and concerns that the EPA and Ecology could have regarding a remedial alternative. The regulatory acceptance process would involve a review and concurrence by the EPA and Ecology. This criterion will be addressed at the time that the Proposed Plan is published.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns that the public may have regarding a remedial alternative. This criterion will be addressed following public review of the Proposed Plan.

6.2 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives under an industrial (exclusive) land-use scenario. This section also presents the NEPA evaluation.

Detailed evaluations were performed on all representative sites and other sites where sufficient data are available. Data obtained at the representative sites were used to evaluate analogous sites. Furthermore, for costing purposes, all sites within 200-TW-1, 200-TW-2, and 200-PW-5 OUs are grouped in logical units for remedial actions. For example, the 216-B-50 Crib is part of the 200-PW-5 OU. However, it is physically located in proximity to the 216-B-46 Crib, a 200-TW-1 OU waste site. Therefore, remedial actions likely would be applied on a physical site basis. As such, the 216-B-50 Crib site is included in the cost evaluation for the 216-B-46 Crib.

The remainder of this chapter is evaluated on a representative site basis. The 216-B-46 Crib is the representative site for the following analogous waste sites:

- The 216-B-43 through 216-B-45 Cribs and the 216-B-47 through 216-B-49 Cribs (located proximal to the 216-B-46 Crib and commonly referred to as the BY Cribs)
- The 216-B-14 through 216-B-19 Cribs (located in the BC Cribs and Trenches area south of the 200 East Area)
- The 216-B-20 through 216-B-22 Trenches (also located in the BC Cribs and Trenches area)
- The 216-B-23 through 216-B-34 Trenches (also located in the BC Cribs and Trenches area)
- The 216-B-42 Trench

- The 216-B-52 Trench (also located in the BC Cribs and Trenches area)
- The 216-BY-201 Settling Tank and the 200-E-14 Siphon Tank
- The 200-E-114 Pipeline
- Unplanned Release UPR-200-E-9.

The 216-T-26 Crib is the representative site for the 216-T-18 Crib. The 216-B-5 Injection/Reverse Well is the representative site for the 216-T-3 Injection/Reverse Well. The 216-B-7A Crib is the representative site for the following analogous waste sites:

- The 216-B-7B, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs
- The 216-T-5 Trench
- The 200-E-45 Sampling Shaft
- The 241-B-361 and 241-T-361 Settling Tanks
- Unplanned Release UPR-200-E-7.

The 216-B-38 Trench is the representative site for the following analogous waste sites:

- The 216-B-35 through 216-B-37 Trenches and the 216-B-39 through 216-B-41 Trenches
- The 216-T-14 through 216-T-17 Trenches
- The 216-T-21 through 216-T-25 Trenches.

The 216-B-57 Crib is the representative site for the following analogous waste sites:

- The 216-B-50 Crib (this crib is one of the BY Cribs located north of the BY Tank Farm)
- The 216-B-11A and 216-B-11B French Drains
- The 216-B-62 Crib
- The 216-C-6 Crib
- The 216-S-9 Crib
- The 216-S-21 Crib
- UPR-200-W-108
- UPR-200-W-109.

The 216-B-58 Trench is the representative site for the analogous waste sites 216-B-53A, 216-B-53B, and 216-B-54 Trenches.

Tables 6-1 through 6-4 provide a summary of the detailed analysis for all of the waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.

6.2.1 Detailed Analysis of Alternative 1: No Action

Alternative 1 is retained for detailed analysis as a baseline description of the effects of taking no action and is required by CERCLA regulations.

6.2.1.1 Overall Protection of Human Health and the Environment

For the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites, the no-action alternative would fail to provide overall protection of human health and the environment because contaminants at concentrations above the PRGs would remain on site with no measures performed to prevent intrusion to the contaminants or to monitor their migration. Because of these circumstances, this alternative fails to meet this criterion under CERCLA for all seven waste site groups.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for any of the seven waste site groups.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For all seven representative sites and their associated analogous waste sites, the no-action alternative fails to provide long-term effectiveness and permanence for human health, because contaminants would remain on site at concentrations that are above the PRGs. Because of these circumstances, this alternative fails to meet this criterion under CERCLA

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are predicted to reach the groundwater at all seven representative sites. Therefore, Alternative 1 does not provide long-term effectiveness for groundwater protection.

Long-Term Effectiveness and Permanence for the Environment. Based on representative site data, three representative sites, the 216-B-46 Crib, the 216-T-26 Crib, and the 216-B-5 Injection/Reverse Well, meet the standard for protection of the environment in the 0 to 4.6 m (0- to 15-ft) bgs zone. The other four representative sites, the 216-B-7A Crib, the 216-B-38 Trench, the 216-B-57 Crib, and the 216-B-58 Trench, have contaminants located in the shallow soils (0 to 4.6 m [0 to 15 ft] bgs). Therefore, these four representative sites fail to meet the protectiveness criterion for the environment.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of the remedy. The no-action alternative does not use any source control or monitoring. Because of the concentrations of contaminants and the substantial length of time required for natural attenuation processes to meet PRGs, this alternative fails to meet this criterion under CERCLA for all seven waste site groups.

6.2.1.5 Short-Term Effectiveness

No short-term worker risks would be associated with the no-action alternative, because remedial activities would not be conducted. Current risks to workers are not an issue because of existing protective soil covers and appropriate safety measures for work activities. Current risks to the environment would not be addressed for the 216-B-7A Crib, the 216-B-38 Trench, the 216-B-57 Crib, and the 216-B-58 Trench, where ecological risk exists (i.e., contaminants are above PRGs in the 0 to 4.6 m [0 to 15-ft] zone). Three representative sites meet the ecological risk criterion. Therefore, this alternative fails to meet this criterion at the three representative sites with shallow contamination.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems. All seven representative sites and their analogous waste sites currently are undergoing in situ natural attenuation.

6.2.1.7 Cost

The no-action alternative would involve no cost.

6.2.2 Detailed Analysis of Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation

Under this alternative, existing soil covers and/or caps would be maintained to provide protection from intrusion by human and/or biological receptors. Legal and physical barriers also would be used to prevent human access to the site. The existing soil covers and/or caps would break the exposure pathway between human and ecological receptors and the contaminants. Groundwater monitoring is included in this alternative.

6.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health and environmental protection within 150 years. Because the viability of institutional controls cannot be ensured past 150 yr, this alternative generally fails to meet this criterion, because the majority of the waste sites would have contamination that would not attenuate within 150 yr. Intruders may be exposed to contaminants at levels above PRGs.

216-B-46 Crib and Its Analogous Sites - All waste sites in this group are assumed to exceed groundwater protection criteria and have intruder risk above 15 mrem/yr at 150 yr, based on the evaluation of the 216-B-46 Crib representative site. The 216-B-46 Crib and the majority of its analogous sites have or are assumed to have significant concentrations of radionuclides just below 4.6 m (15 ft) bgs. These radionuclides pose a considerable threat to intruders (see Table 6-5 and Appendix E for summary of intruder risks). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment.

Two exceptions are the 200-E-114 Pipeline and UPR-200-E-9. The pipeline is a 6 cm (2.4-in.) diameter steel pipe connecting the 216-BY-201 Settling Tank to the 200-E-14 Siphon Tank. Two small leak areas, one near the B Tank Farm, (approximate areal extent of 185.9 m^2 [2,000 ft^2]), where the pipeline turns south, and one near the pipeline's junction with the 216-B-51 French Drain, (approximate areal extent of 182.4 m^2 [1,962.5 ft^2]), are assumed to exceed the criteria for protection of human health and the environment. The UPR site is associated with approximately 41,800 L (11,042 gal) of effluent that overflowed from the 216-BY-201 Settling Tank to the ground. Both of these sites are expected to present risks to human health and the environment because of possible contamination in the 4.6 m (15-ft) bgs zone.

216-T-26 Crib and Its Analogous Site - Both waste sites are assumed to exceed groundwater protection criteria and have intruder risk above 15 mrem/yr at 150 yr, based on evaluation of the 216-T-26 Crib representative site. However, no contamination was present in the 4.6 m (15 ft) bgs zone. The sites have or are assumed to have significant concentrations of radionuclides just below 4.6 m (15 ft). These radionuclides pose a risk to intruders above RAOs (see Table 6-5 and Appendix E). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative is not protective of human health or the environment for these waste sites.

216-B-5 Injection/Reverse Well and Its Analogous Site - Both waste sites are assumed to exceed groundwater protection criteria and have intruder risk above 15 mrem/y, at 150 yr, based on evaluation of the 216-B-5 Injection/Reverse Well representative site. However, no contamination is present in the 4.6 m (15-ft) bgs zone, because contaminants were injected deep in the vadose zone. Waste at both sites was disposed of at depths over 30 m (100 ft) bgs. The 216-B-5 Injection/Reverse Well does not present a continuing risk to human health through direct contact or to the environment. Wastes were injected 92 m (302 ft) bgs approximately 3 m (10 ft) into the water table during the operational period, which ended in 1947. As such, these wastes do not present a risk to an intruder or to the near-surface ecology. Contaminants in the vadose zone at the 216-B-5 Injection/Reverse Well include Cs-137, Sr-90, and Pu-239/240. While these contaminants could continue to impact groundwater, groundwater monitoring in the area does not indicate continued mobilization to the water table. The water table in the area has receded, so impacts from seasonal fluctuations in the water table are not expected.

216-B-7A Crib and Its Analogous Sites - All waste sites in this group are assumed to exceed groundwater protection criteria and have intruder risk above 15 mrem/yr at 150 yr, based on the evaluation of the 216-B-7A Crib representative sites. Additionally, the 216-B-7A Crib, exceeds ecological criteria in the 0 to 4.6 m (0 to 15-ft) bgs zone. The majority of the sites have significant concentrations of radionuclides just below 4.6 m (15 ft). These radionuclides pose a considerable threat to intruders (see Table 6-5 and Appendix E). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment

216-B-38 Trench and Its Analogous Sites - The 216-B-38 Trench and its analogous sites are assumed to exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15-ft) zone, based on the evaluation of the 216-B-38 Trench representative site. The majority of the sites have significant concentrations of radionuclides just below 4.6 m (15 ft). These radionuclides pose a considerable threat to intruders (see Table 6-5 and Appendix E). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment.

216-B-57 Crib and Its Analogous Sites - The 216-B-57 Crib and its analogous sites are assumed to exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15-ft) zone. The majority of the sites have significant concentrations of radionuclides just below 4.6 m (15 ft). These radionuclides pose a risk to intruders above RAOs (see Table 6-5 and Appendix E). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment. An exception is the 216-B-57 Crib, where the Hanford Barrier was installed in the early 1990s. This barrier acts to control infiltration of precipitation and provides layers to eliminate intrusion by humans and ecological receptors. Placement of this barrier is protective of human health and the environment at this site.

216-B-58 Trench and Its Analogous Sites - The 216-B-58 Trench and its analogous sites exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15-ft) zone. In addition, this site exceeds ecological criteria in the 0 to 4.6 m (0 to 15-ft) bgs zone. The majority of the sites in this waste group have significant concentrations of radionuclides just below 3.7 m (12 ft). These radionuclides pose a limited threat to intruders (see Table 6-5 and Appendix E). Contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, ARARs generally would not be met at any of the seven representative sites. Fate and transport modeling indicates that the mobile contaminants (e.g., cyanide, nitrate, nitrite, Tc-99, and uranium) already observed in the groundwater are expected to continue to impact groundwater. The modeling indicates that certain of the other long-lived contaminants (e.g., Ra-226) also may reach the groundwater at concentrations exceeding their MCLs in the future. In the absence of institutional controls, unauthorized intrusive activities to depths greater than 4.6 m (15 ft) bgs would result in unacceptable exposures at most sites. Additionally, four representative sites (216-B-7A Crib, 216-B-38 Trench, 216-B-57 Crib, and 216-B-58 Trench) exceed human health and ecological risk-based PRGs in the 0 to 4.6 m (0 to 15-ft) zone; these PRGs are based on ARARs. Also, one site, the 200-E-114 Pipeline, exceeds risk based PRGs for ecological protection. This site has two small lead areas along the length of the pipeline, which may present an increased risk.

The ARARs are met for the 216-B-57 Crib with the Hanford Barrier. The barrier breaks the exposure pathways between the contaminants and the receptors. Contaminants are up to 12.5 m (41 ft) below the surface of the barrier, thereby reducing to a negligible level the risk associated with intrusion by humans or biota. Intrusion layers incorporated into the cap design provide even more protection. The contaminants will decay to PRG levels in about 330 yr. The life cycle of the Hanford Barrier is about 1,000 yr and will provide long-term protectiveness at the site.

DOE/RL-95-59, *200-BP-5 Operable Unit Treatability Test Report*, concluded that risks from the migration of groundwater at the 216-B-5 Injection/Reverse Well were below levels of concern because of the relative mobility of the principal contaminants (i.e., Cs-137, Sr-90, and Pu-239/240). Similarly, the contaminants in the vadose zone just above the water table are considered to be relatively immobile. Contaminants at these sites were emplaced deep in the vadose zone; in the case of the 216-B-5 Injection/Reverse Well, contaminants were injected at and just above the historical water table level of approximately 86.9 m (285 ft) bgs. An ARAR waiver at these sites may be required for protection of groundwater; however, groundwater impacts are not expected to continue. The contamination in the groundwater will be addressed through the RI/FS process for the 200-BP-5 OU.

6.2.2.3 Additional Considerations

As discussed above, analogous waste sites were evaluated using the representative site data and then applying this information to the known information at each site. Occasionally differences surface with regard to the process history, site size, or potential remedial action. The following sites have site conditions different enough from their associated representative sites to affect the detailed analysis:

- 216-B-51 French Drain - analogous to the 216-B-46 Crib
- 216-BY-201 Settling Tank - analogous to the 216-B-46 Crib
- 200-E-114 Pipeline - analogous to the 216-B-46 Crib
- 200-E-14 Siphon Tank - analogous to the 216-B-46 Crib
- 241-B-361 Settling Tank - analogous to the 216-B-7A Crib
- 241-T-361 Settling Tank - analogous to the 216-B-7A Crib
- 216-T-3 Injection/Reverse Well - analogous to the 216-B-5 Injection/Reverse Well.

The 216-B-51 French Drain received the same type of process waste as the 216-B-46 Crib; however, the quantity of waste received was three orders of magnitude less than the representative site. The 216-B-46 Crib site received 6,700 m^3 (1,770,083 gal) of process waste, while the 216-B-51 French Drain received only an estimated 1 m^3 (275 gal). Given this large volume difference and the nature of the contaminants in the 216-B-46 Crib, the 216-B-51 French Drain site should meet the criteria for overall protectiveness of human health and the environment.

The 216-BY-201 Settling Tank and the 200-E-14 Siphon Tank received the same type of scavenged waste as the 216-B-46 Crib. The 241-B-361 and 241-T-361 Settling Tanks received the same type of 1st and 2nd-cycle waste as the 216-B-7A Crib. The tanks were built to temporarily hold waste before it was discharged to the waste sites. The tanks are not known to have leaked, but are believed to contain some residual sludge. The sludge is assumed to represent all risk associated with these tanks. Once the sludge is removed, the tanks should meet the criteria for overall protectiveness of human health and the environment and for compliance with ARARs.

The threshold criteria also would be met for the 216-E-114 Pipeline, a 5 cm (2-in.) steel pipeline that runs from the BY and C Tank Farms to the 200-E-14 Siphon Tank and the 216-B-14 through 216-B-19 Cribs. The pipeline is buried 2.1 to 3 m (7 to 10 ft) deep and is almost 4.8 km (3 mi) long. The only evidence of leakage was the two small leaks mentioned above. Because of the small diameter, the steel construction, and basic/neutral waste stream, significant leaks along the pipeline are unlikely. Contamination associated with this pipeline is expected to be significantly lower than the associated cribs and trenches and is expected to reach PRGs within the 150-yr institutional control period. The two small areas of know contamination will be removed and disposed of at ERDF. Additionally, a portion of the pipeline will be removed as part of the remediation of the BC Cribs and Trenches area. The removal of this portion, which extends from the BC Cribs to Route 4 South, will provide confirmatory data for the rest of the pipeline to support the remedy selection.

The 216-T-3 Injection/Reverse Well received process waste similar to the 216-B-5 Injection/Reverse Well. This waste was injected deep into the vadose zone at 32 to 62 m (105 to 203 ft) bgs. Contaminants at the two sites are assumed to be similar. Because of the immobile nature of these contaminants, future impacts to the groundwater are not expected at the 216-T-3 Injection/Reverse Well.

6.2.2.4 Long-Term Effectiveness and Permanence

Human Health:

This alternative would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. As mentioned under Alternative 1, natural attenuation is a proven and acceptable technology. This alternative would incorporate the use of institutional controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations beneath the existing soil cover reached acceptable levels. Institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Although institutional controls generally are considered to be proven and acceptable technologies meant to prevent access to residuals, they may not be effective for the extended lengths of time needed to address the contaminants at the waste sites in the 200-TW-1, 200-TW-2, and 200-TW-3 OUs (i.e., hundreds to thousands of years). Institutional control and monitoring would be required for the entire time that contaminants exceed PRGs to be effective. In many of these waste sites, the contaminant concentrations remain sufficiently elevated at 150 yr to have an intruder risk above RAOs. Table 6-5 illustrates the dose and risk to potential intruders associated with the representative sites and analogous waste sites with data at 150 yr.

216-B-46 Crib and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders.

The 216-B-7A Crib has contaminants that would remain beyond the assumed 150-yr institutional control period. The analogous sites for this crib are assumed to have similar contaminants, with the exceptions noted below. Intruders at the 216-B-7A Crib and its analogous waste sites would be exposed to significant radiological doses past 150 years. Given the current concentrations at the representative site and its analogous sites with data, this alternative is not protective in the long term, except at the following sites: at the 216-BY-201 Settling Tank and the 200-E-14 Siphon Tank, where sludge removal will reduce risk levels to meet RAOs; at the 200-E-114 Pipeline, where removal of the two small areas of contamination will reduce risk levels to meet RAOs; and at the 216-B-51 French Drain, where the volume of waste received, 1 m^3 (264 gal) implies little risk at this site.

216-T-26 Crib and Its Analogous Site - Under Alternative 2, chemicals and radionuclides in this group would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The 216-T-26 Crib does not meet the 15 mrem dose to the general public or the CERCLA risk range of 10^{-4}-10^{-6} under the intruder scenario. The representative site also has contaminants that would remain beyond the assumed 150-yr institutional control period. Intruders to these waste sites could be exposed to significant radiological doses past 150 yr.

Given the current concentrations at the 216-T-26 Crib, this alternative is not protective in the long term for the representative site or its analogous waste site.

216-B-5 Injection/Reverse Well and Its Analogous Site - Both waste sites in this group are assumed to exceed groundwater protection criteria. Waste at both sites was disposed of at depths over 30 m (100 ft). As such, these wastes do not present a risk to an intruder or to the near surface ecology. Contaminants in the vadose zone at 216-B-5 Injection/Reverse Well include Cs-137, Sr-90, and Pu-239/240. While these contaminants could continue to impact groundwater, groundwater monitoring in the area does not indicate continued mobilization to the water table. The water table in the area has receded, so impacts from seasonal fluctuations in the water table are not expected. Alternative 2 would include continued monitoring of contaminant movement and would be protective in the long term as long as the monitoring activities are maintained. The treatability test showed that if mobilized to the groundwater, the contaminants were receptive to the pump-and-treat technology.

216-B-7A Crib and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The representative site does not meet the 15 mrem dose to the general public or the CERCLA risk range of 10^{-4} to 10^{-6} under the intruder scenario. The representative site also has contaminants that would remain beyond the assumed 150-yr institutional control period. Intruders to these waste sites could be exposed to significant radiological doses past 150 yr.

At the 241-B-361 and 241-T-361 Settling Tanks, sludge removal will reduce risk levels to meet RAOs; therefore, Alternative 2 is protective in the long term for the settling tanks. Given the current concentrations at the representative site, Alternative 2 is not protective in the long term for the 216-B-7A Crib and the rest of its analogous sites.

216-B-38 Trench and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The representative site does not meet the 15 mrem dose to the general public or the CERCLA risk range of 10^{-4} to10^{-6} under the intruder scenario, and contaminants would remain beyond the assumed 150-yr institutional control period. Intruders to these waste sites could be exposed to significant radiological doses past 150 yr.

Given the current concentrations at the 216-B-38 Trench, this alternative is not protective in the long term for this representative site or its analogous waste sites.

216-B-57 Crib and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The representative site does not meet the 15 mrem dose to the general public or the CERCLA risk range of 10^{-4} to 10^{-6} under the intruder scenario, and contaminants would remain beyond the assumed 150-yr institutional control period. Intruders to these many of these waste sites would be exposed to significant radiological doses past 150 yr.

Based on evaluation of the representative site 216-B-57 Crib, this alternative is not protective in the long term for the analogous sites. This alternative, however, is protective in the long-term for the 216-B-57 Crib, because the Hanford Barrier has been constructed over the waste site. This barrier was designed and built with a 1,000-yr effective life, which exceeds the time needed to reach PRGs at this crib. The barrier provides infiltration and intrusion protection. Results of the treatability testing and continued monitoring at the barrier indicate that it performs very well at preventing infiltration and is very stable.

216-B-58 Trench and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The 216-B-58 Trench does meet the 15 mrem dose to the general public and the CERCLA risk range of 10^{-4} to 10^{-6} under the intruder scenario. Contaminants at 150 yr would still exceed human health and ecological direct exposure PRGs.

Given the current concentrations at the 216-B-58 Trench, this alternative is not protective in the long term for the representative site or its analogous waste sites.

Protection of Groundwater:

216-B-46 Crib and Its Analogous Sites - The 216-B-46 Crib exceeds the groundwater protection PRGs for antimony, cadmium, cyanide, nitrate, uranium, Tc-99, U-238, Co-60, and Ra-226. These contaminants appear as elevated concentrations found throughout the soil column to nearly 67 m (220 ft) bgs. The analogous waste sites with data also have similar contaminants that pose a threat to groundwater. Given the current concentrations at the 216-B-46 Crib and its analogous waste sites with data, this alternative is not protective of the groundwater for the representative site or its analogous waste sites.

216-T-26 Crib and Its Analogous Site - The 216-T-26 Crib exceeds the groundwater protection PRGs for cyanide, nitrate, nitrite, uranium, Tc-99, U-233/234/238, and Pu-239. These contaminants appear as elevated concentrations found throughout the soil column to nearly 61 m (200 ft) bgs. Given the current concentrations at the 216-T-26 Crib, this alternative is not protective of the groundwater for the representative site or its analogous waste site.

216-B-5 Injection/Reverse Well and Its Analogous Site - Contaminants disposed of to the 216-B-5 Injection/Reverse Well were injected at the water table. Contaminants identified in the vadose zone above the water table and in the groundwater include Sr-90, Cs-137, uranium, and Pu-239/240. These contaminants are found throughout the soil column to nearly 86.9 m (285 ft) below ground surface. DOE/RL-95-59 concluded that risks from the migration of groundwater at the 216-B-5 Injection/Reverse Well were below levels of concern because of the relative mobility of the principal contaminants (i.e., Cs-137, Sr-90, and Pu-239/240. Alternative 2 would provide protection to the groundwater by continued monitoring, in association with the depth and relative immobility of the contaminants.

216-B-7A Crib and Its Analogous Sites - The 216-B-7A Crib exceeds the groundwater protection PRGs for cyanide, fluoride, nitrate, Tc-99, U-233/234/238, and Sr-90. These contaminants appear as elevated concentrations found throughout the soil column to nearly 67 m (222 ft) bgs. Given the current concentrations at the 216-B-7A Crib, this alternative is not protective of the groundwater at the representative site or at its analogous waste sites.

216-B-38 Trench and Its Analogous Sites - The 216-B-38 Trench exceeds the groundwater protection PRGs for nitrate, nitrite, uranium, Tc-99, and U-233/234/238. These contaminants appear as elevated concentrations found throughout the soil column to nearly 67 m (220 ft) bgs. Given the current concentrations at the 216-B-38 Trench, this alternative is not protective of the groundwater at the representative site or at its analogous waste sites.

216-B-57 Crib and Analogous Sites - The 216-B-57 Crib exceeds the groundwater protection PRGs for Tc-99, because elevated concentrations are found throughout the soil column to nearly 54 m (177 ft) bgs. Given the current concentrations at the 216-B-57 Crib, this alternative is not protective of the groundwater for the analogous waste sites. This alternative is protective at the 216-B-57 Crib, where the Hanford Barrier is installed.

216-B-58 Trench and Analogous Sites - The 216-B-58 Trench exceeds the groundwater protection PRGs for selenium and nitrate. The other COCs at this site are Cs-137 and Sr-90, both immobile radionuclides. As such, this alternative is not protective of groundwater.

The Environment:

Table 2-7 lists the depths to the top of the contamination for all the waste sites in these OUs. For sites with contamination in the 0 to 4.6 m (0 to 15-ft) zone, ecological risks are assumed, based on the nature of the contamination at the representative sites. Alternative 2 is not considered protective if the contaminants in the 0 to 4.6 m (0 to 15-ft) zone will not reach ecological PRGs within 150 yr. Alternative 2 is considered protective if contaminants are below this zone.

6.2.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation at all of the waste sites. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science-of-natural-attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

While this alternative provides a reduction in the mass of radioactive contaminants at the site, the time needed to meet the PRGs generally is greater than 150 yr. Furthermore, Alternative 2 does not provide a method to limit infiltration into the waste sites and, therefore, does not prevent the mobilization of contaminants to the water table. An exception is the Hanford Barrier on the 216-B-57 Crib. This barrier limits infiltration to the waste zone, thereby reducing the mobility of the contaminants.

6.2.2.6 Short-Term Effectiveness

6.2.2.6.1 Remediation Worker Risk

Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 2, only minimal short-term worker risks are expected at all seven representative sites, associated with monitoring and maintenance activities. Most of the analogous sites have a soil cover associated with backfill after construction and with stabilization activities conducted on the Hanford Site. Therefore, short-term risks to the workers under Alternative 2 are minimal and controllable. Experienced workers using appropriate safety precautions would conduct the maintenance and surveillance activities. Risks would decrease over time as the radionuclides decay. Also, DOE control of the Central Plateau is assumed for at least the next 50 years, given DOE's commitment to vitrify the waste in the tank farms. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.6.2 Impact to Environment During Remediation

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls. Currently, some sites have contamination within the shallow soils from 0 to 4.6 m (0 to 15 ft) (see Table 2-7). As such, short-term impacts to vegetation and wildlife may occur at these sites during the implementation of this alternative. The waste sites have been highly disturbed, and the existing soil cover does provide protection for all but the deeply rooted plants or deep burrowing animals. The short-term impacts to the environment are expected to be low. Sites with contamination below 4.6 m (15 ft) do not present short-term impacts to the environment, because the contaminants are located below the zone of intrusion for vegetation and wildlife.

6.2.2.6.3 Time to Meet the Remedial Action Objectives

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls to eliminate exposure pathways. The RAOs can only be fully met through natural radiological decay of contaminants, which can take hundreds to thousands of years to achieve. Therefore, this alternative does not meet RAOs in a reasonable time frame, with the exception of the following waste sites:

- 216-B-57 Crib, where the Hanford Barrier provides infiltration protection with a life cycle greater than necessary for the contaminants to naturally decay to acceptable levels
- The 216-B-51 French Drain, where only a small volume of waste was discharged
- The 216-BY-201, 241-B-361, and 241-T-361 Settling Tanks and the 200-E-14 Siphon Tank, where removal of the sludge is anticipated to meet the PRGs
- The 200-E-114 Pipeline, where only limited contamination is expected, at leak sites that would not pose a threat to groundwater
- The 216-B-5 and 216-T-3 Injection/Reverse Wells, where the contamination has already reached the groundwater.

6.2.2.7 Implementability

Alternative 2 could be readily implemented and would not present technical problems at any of the representative sites or analogous waste sites. This alternative currently is being implemented through Hanford Site access controls, surface and subsurface radiation area work and access controls, and the waste site/radiation area surveillance and maintenance program. Also, this alternative currently is implemented at the 216-B-57 Crib, where maintenance and monitoring activities have been ongoing successfully since 1994.

6.2.2.8 Cost

Cost estimates for the alternative were developed based on existing costs for similar activities currently conducted on the Hanford Site. Details of the cost estimates are presented in Appendix D. The costs for each waste site, or group of waste sites, are summarized in Table 6-1. The input parameters used in these estimates are the best available at this time, but in many cases the data on contaminants of concern, site locations, and site dimensions are limited. The uncertainties identified above are similar for all of the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

This alternative involves costs for activities similar to current activities. These involve periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews. The present-worth costs assume a 3.2 percent discount rate (based on 2003

Office of Management and Budget information) and assumes an operation and maintenance period equal to the time required for PRGs to be met. Long-term monitoring costs associated with groundwater are not included in this cost estimate, because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.2.3 Detailed Analysis of Alternative 3: Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil and debris (such as concrete or wood associated with cribs) would be removed, treated as necessary to meet waste acceptance criteria, and disposed of to an approved waste disposal facility. Soils would be removed to meet PRGs. Alternative 3 has two disposal paths: one for disposal of soils contaminated with transuranic constituents above 100 nCi/g and one for disposal of soils that are not contaminated above these levels or that do not have transuranic constituents. These latter soils will be disposed of on-site at the ERDF facility. Some soil blending will be required to meet health and safety standards and waste acceptance criteria before the soils are disposed of at the ERDF facility, based on the data collected for the representative and analogous waste sites that have been characterized. Alternative 3 would remove contaminated waste and soil from waste sites to a depth to meet the RAOs. Soil contamination above PRGs is generally at a depth of 4.6 m to 67 m (15 to 220 ft) bgs.

One of the representative sites, the 216-B-7A Crib, was found to have concentrations of Pu-239/240 above 100 nCi/g. The maximum concentration of Pu-239/240 found at this site was 153,000 pCi/g. This site received 4,300 g of plutonium during its operation. Based on process knowledge, estimated inventories received, and the results of the RI work, five other sites may contain transuranic constituents: the 216-B-5 Injection/Reverse Well, 216-T-3 Injection/Reverse Well, 216-T-6 Crib, 216-T-32 Crib, and 216-B-53A Trench. Excavated soil that is determined to contain more than 100 nCi/g of transuranic constituents will be handled, packaged, stored, and ultimately disposed of in accordance with ARARs. Disposal likely will be to the Waste Isolation Pilot Plant.

This alternative generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs. However, under this alternative, workers are exposed to highly contaminated soils with substantial dose rates. Removal of the contaminants provides for the most flexibility for future land use.

In general, the representative sites had contamination to depths near the water table. In addition, contaminant concentrations at the bottom of the representative sites tended to be very high, especially for Cs-137 and Sr-90. Excavation to these depths and in these levels of contamination is difficult, requires workers to be exposed to the high contaminant concentrations as well as risks associated with deep excavations, and has the potential to impact neighboring facilities, such as the tank farms. This type of excavation is expensive and creates considerable waste that requires disposal.

This alternative would provide protection to future humans and the environment because the contaminants are removed from the waste site. The groundwater would be protected. Because contaminants above PRGs would be removed from a waste site and placed in an approved disposal facility, failure of this alternative is not likely. Residual risks would be at acceptable levels for human health, environmental, and groundwater protection. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facility are not evaluated here, but are evaluated as part of the permitting process for the facility.

The contaminants associated with the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites result in significant dose to workers, who would be exposed during the excavation and disposal processes. Table 6-2 summarizes the dose to workers associated with the excavation and disposal process. Special excavation techniques, such as limited excavation lifts, downblending for health and safety, and protection systems (e.g., equipment modifications, decontamination areas) likely would be necessary to support this alternative, which would significantly increase costs and disposal capacity (these are discussed in greater detail in the following subsections).

6.2.3.1 Overall Protection of Human Health and the Environment

216-B-46 Crib and Its Analogous Sites – Contaminants at this representative site extend from 4.6 to 67 m (15 to 220 ft) bgs. High concentrations of Cs-137 and Sr-90 (e.g., 12.9 million pCi/g Cs-137 at the 216-B-48 Crib and 14.2 million pCi/g Sr-90 at the 216-B-47 Crib [concentrations at time of collection in 1992) were found at the bottoms of the waste sites with data.

216-T-26 Crib and Its Analogous Site - Contaminants at this representative site extend from 4.6 to 61 m (15 to 200 ft) bgs. High concentrations of Cs-137 and Sr-90 are found at the bottom of each of the cribs (e.g., 47,900 pCi/g of Cs-137 and 49,100 pCi/g Sr-90).

216-B-5 Injection/Reverse Well and Its Analogous Site - Contaminants at this representative site were found from 73 to 87 m (240 to 285 ft) bgs. Elevated concentrations of Cs-137 (51,300 pCi/g), Sr-90 (60,000 pCi/g), Pu-239/240 (75,000 pCi/g), and Am-241 (2,540 pCi/g) were found just above the water line. Because of the nature of contaminants disposed at this site and data gathered at other sites, both the 216-B-5 and 216-T-3 Injection/Reverse Wells have a potential to contain TRU waste in the excavated soil column.

216-B-7A Crib and Its Analogous Sites - Contaminants at this representative site extend from 4.3 to 67.7 m (14 to 222 ft) bgs. High concentrations of Sr-90 (5.7 million pCi/g), Cs-137 (153,000 pCi/g), and Pu-239/240 (153,000 pCi/g, which is above the definition of TRU waste limits) are found at the bottom of the crib.

216-B-38 Trench and Its Analogous Sites - Contaminants at this representative site extend from 4.6 to 67 m (15 to 220 ft) bgs. High concentrations of Cs-137 were found at the bottom of the trench (226,000 pCi/g).

216-B-57 Crib and Its Analogous Sites - Contaminants at this representative site extend from 4.6 to 54 m (15 to 177 ft) bgs. High concentrations of Cs-137 (2 million pCi/g) and Sr-90 (570,000 pCi/g) were found at the bottom of the crib.

216-B-58 Trench and Its Analogous Sites - Contaminants at this representative site extend from 3.4 to 7.6 m (11 to 25 ft) bgs. Low concentrations of Cs-137 (14,000 pCi/g) were found at the bottom of the trench. Excavation to this depth and in these concentrations is accomplished with standard construction equipment.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with ARARs by removing soil that exceeds the PRGs and by removing structures. Action-specific ARARs, such as worker and environmental exposure standards, may be exceeded under this alternative without proper protection standards during implementation.

6.2.3.3 Long-Term Effectiveness and Permanence

Human Health:

This alternative will remove contaminants to meet human health RAOs. Both EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution at the waste sites; much of the waste would, however, remain on site at the ERDF.

Excavation is a proven and acceptable technology used to remove contaminated soils. However, excavation to depths below 7.6 m (25 ft) bgs can become difficult and require the use of more sophisticated digging techniques, such as the use of approach ramps, extensive removal of clean material to obtain adequately safe side slopes, limited surface exposure, or limited lift removal. Excavation with dust suppression and health and safety controls is proven to handle potential problems with excavating large soil sites.

216-B-46 Crib and Its Analogous Sites - The high concentrations of Cs-137 and Sr-90 associated with these sites pose a significant dose potential to workers. The dose for the excavation of the 216-B-43 through 216-B-50 Cribs is estimated to be 935 rem. The other analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modifications to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

216-T-26 Crib and Its Analogous Site - The high concentrations of Cs-137 and Sr-90 associated with these sites pose a significant dose potential to workers. The dose for the 216-T-26 Crib is estimated to be 0.54 rem. The analogous site will experience similar total dose. As such, special controls and shielding of workers and equipment are necessary.

216-B-5 Injection/Reverse Well and Its Analogous Site - The high concentrations of Cs-137, Sr-90, Am-241, and Pu-239/240 associated with these sites may pose a significant dose potential to workers. More extensive worker protection would be required to implement this alternative. Modification to standard excavation equipment such as shielding, extra long excavation arms (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment may be necessary.

216-B-7A Crib and Its Analogous Sites - The high concentrations of Cs-137, Sr-90, and Pu-239/240 associated with the representative site pose a significant dose potential to workers.

The dose for the 216-B-7A Crib is estimated to be 6 rem. The analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modifications to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

Excavated soils with transuranic constituents above 100,000 pCi/g would be analyzed, treated if necessary, and transported to the Waste Isolation Pilot Plant. The only waste currently identified in this FS as potentially requiring disposal to the Waste Isolation Pilot Plant (e.g., greater than 100,000 pCi/g) is about 8.4 m^3 (300 ft^3) of soil beneath the 216-B-7A Crib. When excavated, this soil must be placed in containers, certified, and transported to the Waste Isolation Pilot Plant.

216-B-38 Trench and Its Analogous Sites - The high concentrations of Cs-137 associated with the representative site pose a significant dose potential to workers. The dose for the 216-B-35 through 216-B-41 Trench waste sites is estimated to be 1,560 rem. The other analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modification to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

216-B-57 Crib and Its Analogous Sites - The high concentrations of Cs-137 and Sr-90 associated with the representative site and analogous sites pose a significant dose potential to workers. The Hanford Barrier exists on the 216-B-57 Crib and, as such, excavating this site is impractical. Therefore, the analytical data from the 216-B-57 Crib was used along with the area of the 216-B-62 Crib was used to evaluate the potential dose to workers. The dose for the 216-B-62 Crib is estimated to be 10.7 rem. The other analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modification to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

216-B-58 Trench and Its Analogous Sites - The concentrations of Cs-137 associated with the 216-B-58 Trench pose a potential dose to workers of 0.04 rem. The analogous sites will experience similar total dose. The 216-B-53A Trench received 100 g of plutonium and may have concentrations of transuranic constituents above 100,000 pCi/g.

Overall Protection of Groundwater:

Contaminants are removed to meet the RAOs and, as such, this alternative meets the objectives of this criterion for all the waste sites.

Overall Protection of the Environment:

All contaminated soil in the 0 to 4.6 m (0 to15 ft) bgs zone is removed under this alternative. Therefore, this criterion is met. Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. These areas would need to be revegetated after disturbance and would require activities to control intrusion by non-native, noxious plants. This should not adversely affect the alternative in the long term or permanently. Because of the large volumes of backfill material that would be needed to fill excavations in excess of 60 m (200 ft), borrow areas would be impacted. Some of the identified borrow areas are in potentially ecologically sensitive areas.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

In general, the removal, treatment, and disposal alternative would include treatment to reduce toxicity, mobility, or volume. However, with the availability of the ERDF, treatment is not anticipated. Radiological decay ultimately results in reduction of toxicity and volume. Based on the information contained in the RI reports, waste at all sites meets the ERDF waste acceptance criteria. When the in situ waste soil exceeds the ERDF waste acceptance criterion of 50 mR/h physical treatment, downblending with less contaminated soil will be performed at the excavation site to meet health and safety and disposal requirements. Movement of the waste to the ERDF will result in reduction of mobility. The ERDF will provide additional protection against remobilization of contaminants over their current location.

6.2.3.5 Short-Term Effectiveness

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 3, dose to the remediation worker would be very high. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), handling, transportation, and disposal. Unprotected workers present an unacceptable risk because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in the waste sites are short-lived radionuclides (Cs-137 and Sr-90) that emit a very high dose. Excavation workers, truck drivers, and waste management workers would be exposed to dose rates that require special protections. These protections would include shielding, HEPA filtration for breathing air, and equipment modification to provide additional shielding from the source. Specific risks are detailed below.

Remediation Worker Risk:

Remediation worker risk for the representative sites is discussed in Section 6.2.3.3. The high concentrations associated with many of these sites would result in high doses to workers and would require special protections during excavation, handling, transportation, and disposal of the excavated soils.

Impact to Environment during Remediation:

Physical disruption of the waste sites during excavation, increased human activity and noise, plus the generation of fugitive dust, will affect local biological resources. Both Cs-137 and Sr-90 have low screening levels for biota. Extra efforts would need to be in place to limit exposure during remediation. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

216-B-46 Crib and Its Analogous Sites - The excavation for the 216-B-46 Crib representative site and all of its analogous sites would cover approximately 77 ha (190 acres).

216-T-26 Crib and Its Analogous Site - The excavation for the 216-T-26 Crib and 216-T-18 Crib would cover approximately 7.4 ha (18.7 acres).

216-B-5 Injection/Reverse Well and Its Analogous Site - The excavation for the 216-B-5 Injection/Reverse Well and 216-T-3 Injection/Reverse Well would cover approximately 11.5 ha (28.4 acres).

216-B-7A Crib and Its Analogous Sites - The excavation for the 216-B-7A Crib representative site and all of its analogous sites would cover approximately 73.5 ha (181.6 acres).

216-B-38 Trench and Its Analogous Sites - The excavation for the 216-B-38 Trench representative site and all of its analogous sites would cover approximately 27.5 ha (68 acres).

216-B-57 Crib and Its Analogous Sites - The excavation of the 216-B-11A and 216-B-11B French Drains, 216-B-62 Trench, 216-C-6 Crib, and 216-C-21 Crib would cover a total of approximately 6.5 ha (15.9 acres).

216-B-58 Trench and Its Analogous Sites - The excavation of the 216-B-58 Trench representative site and all if its analogous sites would cover approximately 0.7 ha (1.8 acres).

Time to Meet the Remedial Action Objectives:

This alternative prevents the risk to human or ecological receptors by moving the source to an engineered disposal facility. Once the contaminants are removed, four of the five RAOs are met. The only RAO not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-46 Crib and Its Analogous Sites -Design and construction of the removal, treatment, and disposal alternative for this waste group would take 67 years to implement.

216-T-26 Crib and Its Analogous Site - Design and construction of the removal, treatment, and disposal alternative for this waste group could take approximately 16 months.

216-B-5 Injection/Reverse Well and Its Analogous Site - Design and construction of the removal, treatment, and disposal alternative for this waste group could take 16 months.

216-B-7A Crib and Its Analogous Sites - Design and construction of the removal, treatment, and disposal alternative for this waste group could take 24 months.

216-B-38 Trench and Its Analogous Sites - Design and construction of the removal, treatment, and disposal alternative for this waste group would take 23 years to implement.

216-B-57 Crib and Its Analogous Sites - Design and construction of the removal, treatment, and disposal alternative for this waste group would take 24 months to implement.

216-B-58 Trench and Its Analogous Sites - Design and construction of the removal, treatment, and disposal alternative for this waste group would take 16 months to implement.

6.2.3.6 Implementability

The excavation of contaminated soils is technically implementable, although more sophistical excavation equipment and techniques, the use of approach ramps, and possibly shoring would be required.

216-B-46 Crib and Its Analogous Sites - To remove soils above the PRGs, the excavation would be advanced to a depth of 67 m (220 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. At the 216-B-43 through 216-B-50 Cribs, the excavation would extend into the existing cap on the 216-B-57 Crib. Excavation at the 216-B-43 through 216-B-50 Cribs encompasses 7.7 ha (19 acres). To remove the contaminants of concern at this group, 22 million m^3 (29 million yd^3) of soil would have to be removed. The contaminated soil would be disposed of at ERDF. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this group is 5.7 million m^3 (7.4 million yd^3). This quantity of contaminated soil represents 97 percent of the available disposal volume at ERDF. As such, this alternative is not practical without additional capacity at the ERDF facility.

216-T-26 Crib and Its Analogous Site - To remove soils above the PRGs, the excavation would be advanced to a depth of 61 m (200 ft). Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. Excavation at the 216-T-26 and 216-T-18 Cribs encompasses 7.4 ha (18.2 acres). To remove the contaminants of concern at this waste site group, 1.6 million m^3 (2.1 million yd^3) of soil would have to be removed. The contaminated soil would be disposed of at ERDF. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this waste group is 9,283 m^3 (12,134 yd^3). This quantity of contaminated soil represents less than 1 percent of the available disposal volume at ERDF.

216-B-5 Injection/Reverse Well and Its Analogous Site - To remove soils above the PRGs, the excavation would be advanced to a depth of 86 m (285 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at these sites, 3.1 million m^3 (4.1 million yd^3) of soil would have to be removed. The contaminated soil at this waste site group is only 2,964 m^3 (3,875 yd^3). Another major uncertainty is the lateral extent of the contamination at this waste site group. Defining the lateral extent of contamination will be done as part of the design effort. Even with this additional sampling, a high degree of uncertainty regarding to the total volume to be disposed will remain because of the limited sample size. If contaminants extend beyond the limits of the excavation, chasing the contaminants until the groundwater RAOs are met would be very difficult. Therefore, removing over 3.1 million m^3 (4 million yd^3) of soil, and considering the large area needed to stockpile the overburden, is considered impractical.

216-B-7A Crib and Its Analogous Sites - To remove soils above the PRGs, the excavation would be advanced to a depth of 67.7 m (222 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at these waste sites, 1.7 million m^3 (22.4 million yd^3) of soil would have to be removed. Excavation at the 216-B-7A and 216-B-7B Cribs extends more than 18 m (60 ft) inside the B Tank Farm and covers 4.3 ha (10.6 acres). This would result in interferences with tank farm underground utilities and process piping. As such, significant coordination would be required to implement this alternative. Contaminated soil meeting the ERDF waste acceptance criteria would be disposed of on site. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this waste group is 63,710 m^3 (83,281 yd^3). Given the interferences at the B Tank Farm, this alternative is not implementable.

Excavated soils with transuranic constituents above 100,000 pCi/g would be analyzed, treated if necessary, and transported to the Waste Isolation Pilot Plant. The only waste currently identified in this FS as potentially requiring disposal to the Waste Isolation Pilot Plant (e.g., greater than 100,000 pCi/g) is about 8.4 m^3 (300 ft^3) of soil beneath the 216-B-7A Crib. When excavated, this soil must be placed in containers, certified, and transported to the Waste Isolation Pilot Plant.

216-B-38 Trench and Its Analogous Sites - To remove soils above the PRGs, the excavation would be advanced to a depth of 67 m (220 ft). Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. Excavation at the 216-B-38 Trench impinges on the BX Tank Farm and covers 10.8 ha (26.6 acres). This would result in interferences with tank farm underground utilities and process piping. To remove the contaminants of concern at these waste sites, 8.9 million m^3 (11.6 million yd^3) of soil would have to be removed. The contaminated soil would be disposed at ERDF. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this waste group is 1.9 million m^3 (2.5 million yd^3). This quantity of contaminated soil represents 33 percent of the available disposal volume at ERDF. As such, this alternative consumes a large portion of the ERDF facility.

216-B-57 Crib and Its Analogous Sites - The 216-B-57 Crib has a surface barrier installed over the crib and, as such, is not considered in the implementability evaluation of this alternative. All of the analogous sites are considered. To remove soils above the PRGs, the excavation would be advanced to a depth of 54 m (177 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. Excavation at all of its analogous waste sites covers 6.5 ha (15.9 acres). This would result in interferences with tank farm underground utilities and process piping. To remove the contaminants of concern at the analogous waste sites, 1.3 million m^3 (1.7 million yd^3) of soil would be removed. The contaminated soil would be disposed of at ERDF. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this waste group is 66,846 m^3 (87,380 yd^3). This quantity of contaminated soil represents approximately 1 percent of the available disposal volume at ERDF. However, given the large volume of excavated soil and large land area need to stockpile the overburden soil, this alternative is considered not practicable.

216-B-58 Trench and Its Analogous Sites - The excavation of contaminated soils is technically implementable for these waste sites. To remove soils above the PRGs, the excavation would be advanced to a depth of 7.3 m (24 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated. To remove the contaminants of concern at these waste sites, 25,289 m3 (33,070 yd^3) of soil would be removed. The contaminated soil would be disposed of at ERDF. The current remaining capacity of ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). The contaminated soil associated with this waste group is 3,457 m^3 (4,519 yd^3). Given the shallow depth of contamination and the lower contamination levels, this alternative is considered implementable for the 216-B-58 Trench and its analogous waste sites.

Another consideration for all the waste sites is coordination with other agencies. Limited coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

Finally, if the entire volume of contaminated soil from all the waste sites were disposed at ERDF, approximately 10.1 million cubic yards of volume would be required for the 200-TW-1, 200-TW-2, and 200-PW-5 OUs. This exceeds the current capacity of ERDF.

6.2.3.7 Cost

Costs, shown on Table 6-2, are based on the use of standard excavation equipment without modifications for use in high dose areas (e.g., hydraulic excavators, front-end loaders, tractor trailers). Modifications to the standard equipment would be determined and would add additional cost to this alternative. This additional cost is considered minor with respect to the cost to implement the alternative and would fall within the CERCLA cost estimate range. Included in the costs are mobilizing personnel and equipment; monitoring, sampling, and analysis; and excavating, transporting the waste to the ERDF, disposing of the waste at the ERDF, backfilling with onsite resources, additional backfilling from a local stockpile, revegetating, and performing prime contractor oversight. The costs are based on the assumption that a subcontractor will do the work, with oversight performed by prime contractor personnel. The cost estimate assumes that the subcontractor personnel are wearing Level C personnel protective equipment (e.g., coveralls and air-filter respirators). Additional detail regarding the cost basis can be found in Appendix D. Costs in Appendix D represent the cost to remove only the radionuclides, except Tc-99, to the PRGs. Chemical contamination and Tc-99 extend deeper into the soil column. To remediate all chemical contaminants and Tc-99, excavations would extend approximately 67.1 m (220 ft) bgs. This additional cost represents an additional $7.8 billion to remove all contaminated soils to meet PRGs.

6.2.4 Detailed Analysis of Alternative 4: Capping

Three types of caps were analyzed for this alternative. The Modified RCRA C barrier was analyzed on all the waste sites except the 216-B-57 Crib. Currently, this site is capped with the Hanford Barrier. As such, the Hanford Barrier was analyzed at this site and at sites with potential transuranic constituents above levels of concern.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative would remove the exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion. The cap would be sufficiently robust to account for the types and levels of contamination in the waste sites. The cap would provide additional distance between potential human and ecological receptors, above and beyond the existing soil covers over the waste sites. Additionally, the cap would include an intrusion layer that would limit unwanted intrusion and provide a warning to potential intruders. Institutional controls including maintenance of the cap, use restrictions, and monitoring would be instituted at capped sites until the PRGs are achieved through natural attenuation. Institutional controls would provide additional protection against human intrusion and would provide for groundwater monitoring as a means of identifying impacts to groundwater. The cap would be designed to address potential failure of the institutional controls and would provide additional intrusion protection past the 150-yr institutional controls period and infiltration control to protect groundwater. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU.

Capping at the 216-B-5 and 216-T-3 Injection/Reverse Wells is impracticable because of the small size of the site and the depth of the contamination. Each of these sites represents an area of less than one square foot. To cap both wells, approximately 148 m^2 (1,600 ft^2) of cap is needed. This represents a 4,600 percent increase of the potentially effected soil.

Capping at the 200-E-114 Pipeline also is impracticable. This site represents an area of less than one square foot per linear foot of pipeline. To cap one linear foot, approximately 154.4 m^2 (1,664 ft^2) of cap is needed. This represents an 8,000 percent increase of the potentially effected soil.

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites by removing the exposure pathway and emplacing caps that meet the intent of the regulations. All of the representative sites have deep contamination except for the 216-B-58 Trench and analogous sites, where contamination is approximately 7.3 m (24 ft) bgs. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.4.3 Long-Term Effectiveness and Permanence

Overall Protectiveness of Human Health:

The capping alternative would be protective of human health and the environment for all waste site groups, except as noted below, by breaking exposure pathways. Chemicals and radionuclides left in place at the waste sites would be physically separated from receptors by the thickness of the cap and by the additional thickness of the existing soil covers. Intrusion layers in the caps would help protect against inadvertent intruders, along with institutional controls such as markers and land-use restrictions. Because contaminants at the waste sites have the potential to impact groundwater, caps will be designed to limit and control infiltration.

Because a significant amount of risk attenuates for the sites within the institutional controls period, failure of the caps in later years would be associated with lower risks than at present (see Table 6-5 for intruder risks and doses). Additionally, the 5-yr reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the caps; adjustments and maintenance activities could be instituted to help prevent failure, based on the 5-yr review results.

The long-term effectiveness depends on the proper construction and maintenance of the barrier and associated institutional controls throughout the natural attenuation time frame to prevent exposure to potential receptors. Maintenance activities would include erosion repairs and vegetation maintenance. Subsidence is not considered a major factor in maintenance activities for these waste sites. Failure of the cap is unlikely if maintenance and institutional control activities are performed on a routine basis. The assumption used is that institutional controls past 150 yr or so would not necessarily be maintained and could fail. Caps would be designed and constructed to account for the necessary time frame to reach PRGs and to minimize maintenance requirements and impacts from institutional controls failure. The modified RCRA C cap has a design life of 500 yr. The waste sites in the 200-TW-1 and 200-TW-2 OUs generally have a significant intruder risk at 150 yr. This necessitates a cap that would protect against intrusion. However, after these contaminants have decayed to acceptable levels, a much less robust cap would be needed, such as a simpler ET barrier to protect the groundwater. If replacement of the cap is necessary at 500 or more years, the replacement cap would be less costly. The following discussion provides the time frames for the short-lived COCs that contribute most significantly to intruder risk to decay to reach PRGs.

In addition, management controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance ET, limit erosion, and blend the site area into the surrounding landscape.

216-B-46 Crib and Its Analogous Sites – Short-lived contaminants of concern (e.g., Cs-137 and Sr-90) for this representative site will reach PRGs for intruder risk in approximately 410 yr; therefore, intruder cap would not require replacement. A groundwater protection cap may still be needed to address nitrate, Tc-99, U-238, and Ra-226 contamination.

216-T-26 Crib and Its Analogous Site – Short-lived contaminants of concern (e.g., Cs-137 and Sr-90) for this representative site will reach PRGs for intruder risk in approximately 330 yr; therefore, the intruder cap would not require replacement. A groundwater protection cap may still be needed to address nitrate, uranium, Tc-99, and Pu-239 contamination.

216-B-5 Injection/Reverse Well and Its Analogous Site - The effectiveness of capping for these sites is uncertain. Both sites are 8-in.-diameter wells installed at 92 m and 62 m (285 ft and 204 ft) bgs, respectively. Capping represents a 4,600 percent increase in area of the potentially effected soil at each site. The contaminants in the vadose zone just above the water table are considered relatively immobile. In addition, because of the potential for waste to contain transuranic constituents in excess of 100 nCi/g, a Hanford-type barrier would be needed.

216-B-7A Crib and Its Analogous Sites - Contaminants of concern for the representative site include transuranic constituents above 100 nCi/g. Because of this contamination, a Hanford Barrier would provide additional protection and design life. Replacement of the cap could be required after the 1,000-yr design life.

216-B-38 Trench and Its Analogous Sites – Short-lived contaminants of concern (e.g., Cs-137) for this representative site will reach PRGs for intruder risk in approximately 400 yr; therefore, the intruder cap would not require replacement. A groundwater protection cap may still be needed to address nitrate, uranium, and Tc-99.

216-B-57 Crib and Its Analogous Sites – Short-lived contaminants of concern (e.g., Cs-137 and Sr-90) for this representative site will reach PRGs for intruder risk in approximately 330 yr; therefore, the intruder cap would not require replacement. A groundwater protection cap may still be needed to address nitrate and Tc-99 for the analogous sites. The Hanford Barrier at the 216-B-57 Crib is not likely to require replacement as the Tc-99 concentrations were not significantly elevated or extensive.

216-B-58 Trench and Its Analogous Sites – Short-lived contaminants of concern (e.g., Cs-137 and Sr-90) for this representative site will reach PRGs for intruder risk in approximately 279 yr; therefore, the cap would not require replacement.

Overall Protection of Groundwater:

This alternative is protective of the groundwater at all waste group sites, because it limits infiltration at the waste site. The caps form a protective barrier from infiltration and intruder risk until RAOs are met. Also, the 5-yr review would focus on groundwater protection monitoring and effectiveness of the cap in addressing the mobile contaminants at depth (e.g., Tc-99, nitrates).

Overall Protection of the Environment

This alternative would provide protection to the environment at of all the representative sites and their analogous waste sites by placing a barrier between the waste and the surface flora and fauna. The caps will be design to prevent the intrusion of deep-rooted flora and burrowing fauna below the 4.6 m (15 ft) bgs level.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

The capping alternative would address the mobility of contaminants by limiting infiltration to the vadose zone, thereby limiting the driving force to move contaminants to the groundwater. Natural attenuation is an important treatment component of the capping alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides. The EPA has stated in its guidance on monitored natural attenuation (EPA/540/R-99/009) that natural attenuation processes "act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater." Thus, the guidance acknowledges that natural attenuation can be a viable treatment action where its use will be protective of human health and the environment. The capping alternative would rely on natural attenuation processes (most importantly radioactive decay) to reduce radioactivity to levels that would not present a risk to human health or the environment. The cap also would significantly reduce the infiltration, thereby reducing the mobility of the contaminants.

6.2.4.5 Short-Term Effectiveness

Remediation Worker Risk:

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 4, only moderate short-term risks are expected. The capping alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the cap. If structures were removed, workers could be exposed to potentially contaminated debris. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

Impact to Environment during Remediation:

Physical disruption of the waste sites during excavation, increased human activity and noise, and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats.

Cesium-137 and Sr-90 have low screening levels for biota, and exposure during remediation could be at unacceptable levels if controls were not in place to limit access.

Construction activities at the waste sites and at borrow areas could disrupt wildlife in the area because of increased noise and human activity. However, most of the waste sites are located in areas already disturbed by earlier facility operations and in areas adjacent to ongoing facility operations, so impacts on biological resources would be low.

Time to Meet the Remedial Action Objectives:

The time to meet the PRGs exceeds the 150-yr institutional control period. As such, these caps will be designed to meet the time frame needed to meet the RAOs. The caps would act to eliminate exposure pathways immediately upon installation.

6.2.4.6 Implementability

The capping alternative is considered implementable at all waste sites. A prototype Hanford Barrier has been implemented at the Hanford Site at the 216-B-57 Crib (CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002).* Other types of barriers (including the modified RCRA C cap) have not been used at the Hanford Site, but have been implemented at other sites and are easy to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics.

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require minor repair and possibly replacement during the restoration time frame. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data (e.g., ground penetrating radar), because existing data may not be adequate for determining the lateral extent of the caps.

Gravel, sand, and silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C currently is being evaluated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material, especially for a multilayered cap, would affect areas of potential ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap. Materials, such as rip rap, that may be used in the cap construction could be obtained on the Hanford Site or could be purchased from local dealers.

Capping materials hauled to the Central Plateau from borrow areas and gravel pits within the Hanford Site would increase heavy equipment use and transportation activities at the sites. However, radioactive or hazardous waste would not have to be hauled away from the Site.

216-B-5 Injection/Reverse Well and Its Analogous Site - While technically implementable, the effectiveness of capping at these sites is uncertain. Both sites are 8-in.-diameter wells installed at 92 m and 62.2 m (285 ft and 204 ft), respectively. Capping represents a 4,600 percent increase in area of the potentially affected soil at each site. The contaminants in the vadose zone just above the water table are considered relatively immobile. In addition, because of the potential for transuranic constituents at concentrations above 100 nCi/g, a Hanford-type barrier would be needed.

6.2.4.7 Cost

Costs, shown in Table 6-3, include stabilization of the existing site; excavation or import, transportation, and placement of capping material; compaction of the cap; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assumes operation and maintenance for 150 yr. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.2.5 Detailed Analysis of Alternative 5: Partial Removal, Treatment, and Disposal with Capping

This alternative includes the removal of contaminants extending to depths shown on Table 5-3. The excavation would be filled with borrow material obtained on the Hanford Site. When the backfilling operation was finished, the site would be capped. These activities remove a significant fraction of the near-surface contaminant load and still provide protection to the groundwater from deeper contaminants that are impracticable to remove. The removal, treatment, disposal, and capping activities would be the same as those described earlier. This alternative is not applicable to sites where contamination is shallow with no deep component or where contamination is very deep with no shallow component.

6.2.5.1 Overall Protection of Human Health and the Environment

This alternative would break potential exposure pathways to receptors through placement of a cap to limit infiltration at this waste group, except as noted below. The cap would provide additional distance between potential human and ecological receptors. The partial removal activity would remove the high contamination zone at the bottom of the waste site, leaving only the lower concentration, deeper contaminants that mainly pose a risk to groundwater. Partial removal of the more shallow contamination would reduce human health and ecological risk for those sites where contamination is in the 0 to 4.6 m (0 to 15-ft) bgs zone and intruder risk associated with the high concentrations at the bottom of the waste site (see Appendix E). While, in the long term, this alternative is protective of human health and the environment, the risk to workers during the excavation are essentially the same as for Alternative 3, because the material being removed under Alternative 5 is the same material that causes the dose for the full-excavation alternative.

Institutional controls including maintenance of the cap, land-use restrictions, and monitoring would be instituted at capped sites until the RAOs are achieved through natural attenuation. The cap would be designed to maximally limit infiltration. Institutional controls would provide additional protection for groundwater monitoring by providing a means to identify potential impacts to groundwater. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU. Those sites where this alternative is not applicable are discussed in the following text.

216-B-46 Crib and Its Analogous Sites - Implementing this alternative at the 200-E-114 Pipeline, the 200-E-14 Siphon Tank, the 216-BY-201 Settling Tank, and UPR-200-E-9 is not practical. These sites are assumed to only have shallow contamination, or in the case of the tanks, contamination associated only with the sludge.

216-B-5 Injection/Reverse Well and Its Analogous Site - Implementing this alternative for these waste sites is not practical. The contamination was injected deep into the vadose zone. As such, no surface contamination is present.

216-B-7A Crib and Its Analogous Sites - Implementing this alternative at the 241-B-361 and 241-T-361 Settling Tank is not practical. The sludge at these sites is assumed to contain all the risk; removal of the sludge would result in these sites meeting RAOs.

216-B-57 Crib and Its Analogous Sites - Implementing this alternative at the 200-B-57 Crib is not practical. This site is covered with the Hanford Barrier and as such is already protective of human health and the environment.

216-B-58 Trench and Its Analogous Sites – Implementing this alternative at these waste sites is not applicable. Based on the results of the investigation at the 216-B-58 Trench, these sites are assumed to have only shallow contamination and would not require a cap to protect deeper contaminants.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5 would comply with ARARs for the waste sites by breaking the pathways for exposure and emplacing caps that meet the intent of the groundwater protection regulations. All of the representative sites waste groups have deep contamination, except the 216-B-58 Trench and its analogous sites, where contamination is approximately 7.3 m (24 ft) bgs. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative. Worker protection ARARs may not be met without extreme measures to control exposure.

6.2.5.3 Long-Term Effectiveness and Permanence

Human Health:

216-B-46 Crib and Its Analogous Sites - This alternative will remove contaminants to a depth of between 7.6 and 9 m (25 and 30 ft) bgs. The high concentrations of Cs-137 (12.9 million pCi/g) and Sr-90 (14.2 million pCi/g) pose a significant dose potential to workers. The dose for just the 216-B-43 through 216-B-50 Cribs is estimated to be 935 rem. The analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modifications to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

These sites generally have contaminants that would remain beyond the assumed 150-yr institutional control period and would pose a significant risk to intruders (see Appendix E). Intruder dose for the 216-B-46 Crib for a future rural residential intruder would be 137 mrem/yr under the no-action alternative. Partial removal of the contamination to between 7.6 and 9 m (25 and 30 ft) would reduce the intruder dose to less than 15 mrem/yr. However, excavating to 9 m (30 ft) for several analogous sites produces an unacceptable dose to workers. The cap would provide protection for groundwater from the remaining contaminants. Further, no data exist beyond the 9 m (30 ft) level to verify the depth of excavation to reach acceptable dose levels. The environment would be protected because accessible contaminants would be removed.

216-T-26 Crib and Its Analogous Site - This alternative will remove contaminants to 12 m (40 ft) bgs. The high concentrations of Cs-137 (47,900 pCi/g) and Sr-90 (49,100 pCi/g) associated with these sites pose a substantial dose potential to workers. The worker dose for the 216-T-26 Crib is estimated to be 0.54 rem. The analogous site will experience similar total dose. As such, special controls and shielding of workers and equipment are necessary.

These sites generally have contaminants that would remain beyond the assumed 150-yr institutional control period and would pose a significant risk to intruders (see Appendix E). Intruder dose for the 216-T-26 Crib for a future rural residential intruder would be 25 mrem/yr under the no action alternative. Partial removal of the contamination to 12 m (40 ft) bgs would reduce the intruder dose to less than 15 mrem/yr. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected because accessible contaminants would be removed.

216-B-5 Injection/Reverse Well and Its Analogous Site - This alternative is not applicable to these waste sites.

216-B-7A Crib and Its Analogous Sites - This alternative will remove contaminants to a depth of 8.5 m (28 ft) bgs. The high concentrations of Cs-137 (153,000 pCi/g), Sr-90 (5.7 million pCi/g), and Pu-239/240 (153,000 pCi/g) associated with these sites pose a significant dose potential to workers. The dose for the 216-7A Crib is estimated to be 6 rem. The analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modifications to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

Excavated soils with transuranic constituents above 100,000 pCi/g would be analyzed, treated if necessary, and transported to the Waste Isolation Pilot Plant. The only waste currently identified in this FS as potentially requiring disposal to the Waste Isolation Pilot Plant (e.g., greater than 100,000 pCi/g) is about 8.4 m^3 (300 ft^3) of soil beneath the 216-B-7A Crib. When excavated, this soil must be placed in containers, certified, and transported to the Waste Isolation Pilot Plant.

These sites generally have contaminants that would remain beyond the assumed 150-yr institutional control period and would pose a significant risk to intruders (see Appendix E). Intruder dose for the 216-B-7A Crib for a future rural residential intruder would be 124 mrem/yr under the no-action alternative. Partial removal of the contamination to 8.5 m (28 ft) bgs would reduce the intruder dose to less than 15 mrem/yr. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected because accessible contaminants would be removed.

216-B-38 Trench and Its Analogous Sites – This alternative will remove contaminants to a depth of 11 m (36 ft). The high concentrations of Cs-137 (226,000 pCi/g) associated with these sites pose a significant dose potential to workers. The dose for the 216-B-35 through 216-B-41 Trenches is estimated to be 1,560 rem. The other analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modification to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

These sites generally have contaminants that would remain beyond the assumed 150-yr institutional control period and would pose a significant risk to intruders (see Appendix E). Intruder dose for the 216-B-38 Trench for a future rural residential intruder would be 109 mrem/yr under the no-action alternative. Partial removal of the contamination to 11 m (36 ft) bgs would reduce the intruder dose to below 15 mrem/yr. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected because accessible contaminants would be removed.

216-B-57 Crib and Its Analogous Sites - This alternative will remove contaminants to a depth of 10.4 m (34 ft) bgs. The high concentrations of Cs-137 (2 million pCi/g) and Sr-90 (570,000 pCi/g) associated with these sites pose a significant dose potential to workers. The dose for the 216-B-62 Crib is estimated to be 10.7 rem. The other analogous sites will experience similar total dose. Extraordinary worker protection would be required to implement this alternative. Modification to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary.

These sites generally have contaminants that would remain beyond the assumed 150-yr institutional control period and would pose a significant risk to intruders (see Appendix E). Intruder dose for the 216-B-57 Crib for a future rural residential intruder would be 35 mrem/yr under the no-action alternative. Partial removal of the contamination to 10.4 m (34 ft) bgs would reduce the intruder dose to below 15 mrem/yr. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected because accessible contaminants would be removed.

216-B-58 Trench and Its Analogous Sites - Alternative 5 is not applicable to these waste sites.

Overall Protection of Groundwater:

Alternative 5 would protect groundwater through placement of a cap that would limit infiltration. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are protective elements of this alternative.

Overall Protection of the Environment:

All contaminated soil in the 0 to 4.6 m (0 to 15-ft) bgs zone is removed in this alternative. Therefore, this alternative provides overall protection to the environment following implementation. The environment could be impacted through removal activities, capping activities, and activities at borrow sites. The impacts at the waste sites are expected to be minimal, because the sites have been highly disturbed and have generally poor quality habitat. Some borrow areas may be located in potentially ecologically sensitive areas.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The partial removal, treatment, and disposal with capping alternative would address the mobility of contaminants by removing a portion of the contaminants and limiting infiltration to the vadose zone, thereby limiting the mass and driving force to move contaminants to the groundwater. Natural attenuation is an important treatment component of this alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides.

When the waste soil exceeds the ERDF waste acceptance criteria physical treatment standard, downblending with less contaminated soil, will be performed in the excavation site. Movement of the waste to the ERDF will result in a perceived reduction of mobility, because ERDF is a potentially less mobile environment that includes monitoring. However, most of the contaminants that would be removed do not pose a risk to groundwater.

6.2.5.5 Short-Term Effectiveness

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 5, dose to the remediation worker would be very high. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), handling, transportation, and disposal. Unprotected workers present an unacceptable risk because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in the waste sites are short-lived radionuclides (Cs-137 and Sr-90) that emit a very high dose. Excavation workers, truck drivers, and waste management workers would be exposed to dose rates that require special protections. These protections would include shielding, HEPA filtration for breathing air, and equipment modification to provide additional shielding from the source.

Remediation Worker Risk:

Specific worker risks were discussed in Section 6.2.5.3.

Impact to Environment during Remediation:

Impacts to the environment during remediation were discussed in Section 6.2.5.3.

Time to Meet the Remedial Action Objectives:

216-B-46 Crib and Its Analogous Sites - Design and construction of the partial removal, treatment, disposal, and capping activities for these waste sites could take approximately 8 yr. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-T-26 Crib and Its Analogous Site - Design and construction of the partial removal, treatment, and disposal with capping alternative for these waste sites would take approximately 19 months. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-5 Injection/Reverse Well and Its Analogous Site – Alternative 5 is not applicable to these waste sites.

216-B-7A Crib and Its Analogous Sites - Design and construction of the partial removal, treatment, disposal, and capping activities for these waste sites could take approximately 40 months. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-38 Trench and Its Analogous Sites - Design and construction of the partial removal, treatment, disposal, and capping activities for these waste sites could take approximately 10 years. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-57 Crib and Its Analogous Sites - Design and construction of the partial removal, treatment, disposal, and capping activities for this waste group could take approximately 5 years. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-58 Trench and Its Analogous Sites – Alternative 5 is not applicable to these waste sites.

6.2.5.6 Implementability

The implementability of this alternative is similar to Alternatives 3 and 4. The excavation of contaminated soils is technically implementable, although the use of more sophisticated excavation equipment and techniques would be required for the high dose areas. The implementation of this alternative would reduce the contaminant mass at the base of the waste sites at depths up to 13.7 m (45 ft) bgs. The aboveground structures (e.g., vent pipes) associated with the waste sites would be removed. Every 0.3 m (1 ft) of excavation would required 0.9 m (3 ft) of side slope for a 1:3 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable. All excavated material would be disposed of at the onsite disposal facility (ERDF) or, if needed, at the Waste Isolation Pilot Plant. The current remaining capacity of ERDF is 7.65 million m^3 (as of February 6, 2004).

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require repair during the restoration timeframe. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data (e.g., ground penetrating radar) and possibly confirmatory sampling, because existing data may not be adequate for determining the lateral extent of the caps.

Gravel, sand, and silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C currently is being evaluated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material would affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap.

Limited coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

216-B-46 Crib and Its Analogous Sites - The contaminated soil volume for these waste sites is 397,303.5 m^3 (519,351 yd^3). Therefore, capacity exists at ERDF to meet the required disposal volume under this alternative.

216-T-26 Crib and Its Analogous Site - The contaminated soil volume for these waste sites is 1,122.2 m^3 (1,467 yd^3). Therefore, capacity exists at ERDF to meet the required disposal volume under this alternative.

216-B-5 Injection/Reverse Well and Its Analogous Site – This alternative is not applicable to these waste sites.

216-B-7A Crib and Its Analogous Sites- The contaminated soil volume for these waste sites is 2,391.4 m^3 (3,126 yd^3). Therefore, capacity exists at ERDF to meet the required disposal volume under this alternative. Excavated soils with transuranic constituents above 100,000 pCi/g would be analyzed, treated if necessary, and transported to the Waste Isolation Pilot Plant. The only waste currently identified in this FS as potentially requiring disposal to the Waste Isolation Pilot Plant (e.g., greater than 100,000 pCi/g) is about 8.4 m^3 (300 ft^3) of soil beneath the 216-B-7A Crib. When excavated, this soil must be placed in containers, certified, and transported to the Waste Isolation Pilot Plant.

216-B-38 Trench and Its Analogous Sites - The contaminated soil volume for these waste sites is 94,661.9 m^3 (123,741 yd^3). Therefore, capacity exists at ERDF to meet the required disposal volume under this alternative.

216-B-57 Crib and Analogous Sites - A prototype Hanford Barrier has been implemented at the Hanford Site at the 216-B-57 Crib (CP-14873). Other types of barriers have not been used at the Hanford Site, but have been implemented at other sites and are easy to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics. The contaminated soil volume for these waste sites is 12,302 m^3 (16,081 yd^3). Therefore, capacity exists at ERDF to meet the required disposal volume under this alternative.

216-B-58 Trench and Analogous Sites – This alternative is not applicable to these waste sites.

6.2.5.7 Cost

Costs, shown on Table 6-4, include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the cap; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assumes operation and maintenance for the length of time needed to reach PRGs. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.3 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences, then to take actions that protect, restore, and enhance the environment. Secretarial policies (DOE 1994) and DOE O 451.1A require that

CERCLA documents incorporate NEPA values, such as analysis of cumulative, offsite, ecological, and socioeconomic impacts, to the extent practicable, in lieu of preparing separate NEPA documentation for CERCLA activities.

6.3.1 Description of National Environmental Policy Act of 1969 Values

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis frequently is directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16; "Environmental Impact Statement," "Environmental Consequences") specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources, air quality, and cultural and historical resources; noise; visual, and aesthetic effects; environmental justice; and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources. The NEPA-related resources and values that DOE has considered in this evaluation include the following.

- Transportation Impacts. This value considers impacts of the proposed remedial action on local traffic (e.g., traffic at the Hanford Site) and traffic in the surrounding region. Transportation impacts are considered in part under the CERCLA criteria of short-term effectiveness or implementability.

- Air Quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.

- Natural, Cultural, and Historical Resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties on the Central Plateau.

- Noise, Visual, and Aesthetic Effects. This value considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.

- Socioeconomic Impacts. This value considers impacts pertaining to employment, income, and other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.

- Environmental Justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.

- Cumulative Impacts (Direct and Indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities on the Central Plateau, at the Hanford Site, or in the region.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identifies required mitigation activities.

- Irreversible and Irretrievable Commitment of Resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.

6.3.2 Detailed Evaluation of the National Environmental Policy Act of 1969

6.3.2.1 Transportation Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on local traffic and traffic in the surrounding region. For Alternatives 4 and 5, impacts would result from hauling cover material to the waste site areas. For Alternative 3 and 5, these impacts would result from hauling waste to the ERDF and hauling clean fill to the waste sites. For Alternatives 3, 4, and 5, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. To mitigate these impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor.

For Alternatives 3 and 5, there may be a need to ship about forty 55-gal drums of TRU-contaminated soil to the Waste Isolation Pilot Plant, which would occur if a thin layer of soil beneath the 216-B-7A Crib is determined to have concentrations of transuranic constituents greater than 100 nCi/g.

6.3.2.2 Air Quality

No current air quality impacts are associated with Alternative 1; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion. This also is true for Alternative 2. Potential near-term impacts to air quality associated with Alternatives 3, 4, and 5 are expected to be minor and could be mitigated through appropriate engineering controls.

Potential air quality impacts primarily would be associated with fugitive dust during site preparation, structure demolition, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (using both water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

6.3.2.3 Natural, Cultural, and Historical Resources

Alternative 1 would not disturb or destroy natural, cultural, or historical resources; however, in some sites, biologic resources could be exposed to contaminants with potential impacts. Alternative 2 would limit access to these resources. Alternatives 3 and 4 could affect cultural or natural resources, although the impacts could be mitigated. Therefore, adverse impacts to cultural resources could occur, if such resources were encountered and appropriate mitigating actions were not taken. Adverse impacts would be minimized by avoiding known cultural resources and traditional-use areas whenever possible. Most of the waste sites are located within areas previously disturbed by operations, so the potential for unknown cultural resources is low. Therefore, although cultural resources could be encountered with Alternatives 3 and 4 during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation was begun. Known cultural resources and traditional-use areas would be avoided whenever possible. If cultural resources were encountered during excavation, the State Historic Preservation Office and Native American Tribes would be consulted about minimizing impacts and taking appropriate actions for resource documentation or recovery.

Some short-term adverse impacts to natural resources (e.g., local wildlife) could occur during the construction and implementation phases of remedial action. Ecological surveys would be performed to identify the species present and the special precautions that should be taken to minimize adverse impacts. Alternatives 3 and 4 also would have positive impacts on natural resources. The potential for exposure to contaminants would be minimized through either waste removal or barrier construction, and the sites would be revegetated.

6.3.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternative 3 would increase noise levels and impair visual values, but the impacts would be short term during remedial actions and ultimately would improve the aesthetics by removing remaining site structures (e.g., retention basins, small shack). Likewise, Alternative 4 would increase noise levels and impair visual values in the short term during construction of the cap. These two alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the caps over large distances if they are not contoured to blend in with the surrounding area. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.5 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other four alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern because future surface uses on the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions. Under Alternatives 1, 2, 4, and 5, environmental justice impacts would be minimal because future-use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial land use.

6.3.2.7 Irreversible and Irretrievable Commitment of Resources

Alternatives 3, 4, and 5 would require some irreversible or irretrievable commitment of natural resources. All of the alternatives with the exception of Alternative 1 would result in some land-use loss. Alternatives 3, 4, and 5 would require additional soils, including materials that could come from potentially ecologically sensitive areas, and some energy resources. They would require a commitment of resources in the form of land-use loss in the waste site areas until remedial action objectives and goals were met through the natural attenuation process. The amount of land-use loss would vary among alternatives. Alternative 2 generally would require land-use loss of the entire site surface and subsurface for the necessary attenuation period to meet remedial action objectives. Alternative 3 generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs immediately following implementation. Alternatives 4 and 5 would allow surface use of the sites but would not allow any subsurface site use until the end of the necessary attenuation period to meet RAOs. This use would be limited based on potential impacts to surface-barrier integrity.

For Alternatives 3 and 5, the ERDF would need to be expanded to accommodate the additional waste. Implementation of the alternative also would require limited waste disposal to the ERDF. The waste volumes from the aboveground structure demolition in Alternatives 3, 4, and 5 are relatively small and are not anticipated to specifically require additional ERDF capacity.

Alternatives 3, 4, and 5 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With Alternatives 3 and 5, excavated material would be replaced with a stockpile of clean soil cover removed from the site, if not used to downblend for health and safety purposes, as well as clean sand and gravel fill from onsite borrow pits. The sand and gravel for the surface-barrier alternative would come from nearby borrow pits, but the silt would need to come either from the Fitzner-Eberhardt Arid Lands Ecology Reserve or from offsite. Rip-rap or other armouring materials needed to provide intrusion protection likely would come from offsite.

6.3.2.8 Cumulative Impacts

The proposed RAOs could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the Hanford Site include a privately owned radioactive and mixed waste treatment facility, a commercial fuel manufacturer, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation; air quality; and natural, cultural, and historical resources. Noise, visual and aesthetic effects, and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying degrees, Alternatives 2, 3, 4, and 5 would result in the loss of some land uses on the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. Alternatives 3 and 5 also would require a commitment of land use as a result of the ERDF expansion on the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use on the Central Plateau.

Under Alternatives 3, 4, and 5, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551) and may be subject to a separate NEPA evaluation.

6.3.2.9 Mitigation

Alternative 1 would not include mitigation. Mitigation measures under Alternative 2 would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3, 4, and 5 would include dust suppression, stockpiling clean topsoil for reuse, minimizing the size of construction areas, and planning activities to avoid nesting and breeding cycles of birds and mammals. For Alternatives 4 and 5, surveillance and physical controls may be used.

6.3.2.10 Summary of National Environmental Policy Act of 1969 Evaluation

Remedial actions at the Central Plateau waste sites would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be very large, nor would they vary greatly among the remedial alternatives.

Figure 6-1. Logic Diagram for Selecting Applicable Alternatives.

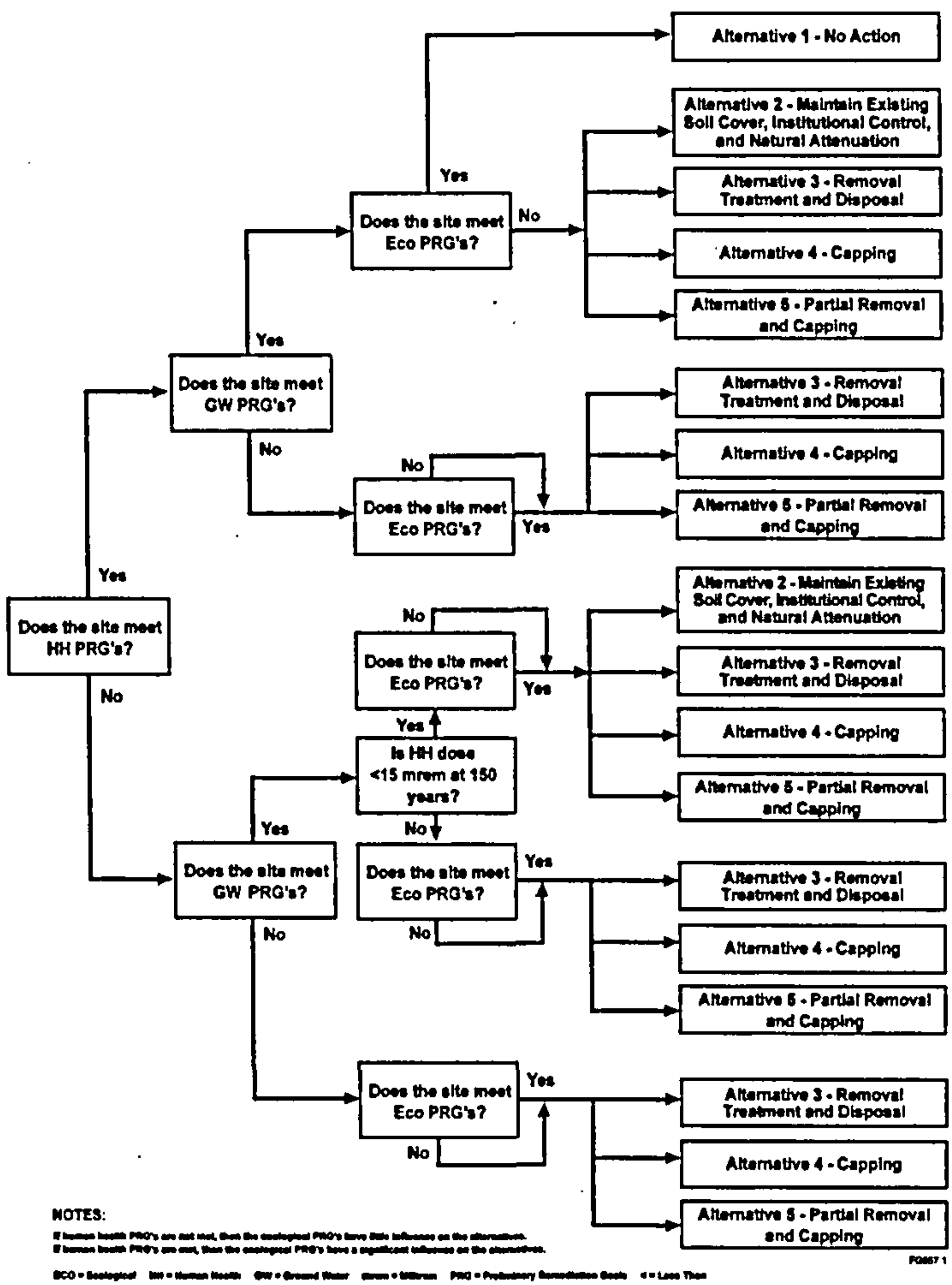

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Representative Site							
216-B-46 Crib	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks not expected because contaminants are below 4.6 m (15 ft) bgs	Readily implementable	$1,728
Analogous Sites with Characterization Data							
216-B-43 through 216-B-45, 216-B-47 through 216-B-50 Cribs	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks not expected because contaminants are below 4.6 m (15 ft) bgs	Readily implementable	Included in representative site above
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs and 216-B-20 through 216-B-34, 216-B-42, and 216-B-52 Trenches	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks may be expected if contaminants are less than 4.6 m (15 ft) bgs	Readily implementable	$23,970
216-BY-201 Settling Tank and 200-E-14	Sludge poses greatest risk because tanks are not thought to	Complies with ARARs by removal of sludge; complies with disposal	After sludge is removed, only minimal risk remains; no	Reduction through natural attenuation of	Short-term risks to workers are anticipated to be high for removal	Readily implementable	$12,248

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Siphon Tank	have leaked; after sludge removal, only minimal contamination is expected; remaining contamination is anticipated to reach PRGs within 150 yr	requirements	anticipated risk to groundwater	radionuclides; sludge would be treated as required to meet waste acceptance criteria	of the sludge; no short-term risks associated with implementation of Alternative 2; minimal short-term impacts to vegetation and wildlife associated with sludge removal		
200-E-114 Pipeline	Contaminants are expected to be minimal because pipeline is 5 cm (2 in) diameter steel with known leaks only at head end; any contamination is expected to attenuate naturally to meet PRGs within 150 years; pipeline is 2 to 3 m (7 to 10 ft) bgs; institutional controls provide additional protection	Complies with ARARs by eliminating pathway; meets PRGs within 150 yr	Contamination is expected to be low; a portion of the pipeline will be removed near the BC Cribs and Trenches to provide data on rest of the pipeline	Reduces through natural attenuation of radionuclides	No short-term worker risk as contaminants are 2 to 3 m (7 to 10 ft) deep; short-term ecological impacts are not expected because contaminants are low and at or below the average rooting/animal intrusion depth	Readily implementable	$1,711
216-B-51 French Drain	Very small site; received only about 1 m³ of effluent; not expected to impact groundwater; contaminant concentrations are expected to be low and to reach PRGs through natural attenuation within 150 yr	Complies with ARARs because human health, ecological, and groundwater protection requirements are assumed to be met through the use of existing soil cover and institutional controls; PRGs are met within the 150-yr institutional control period	Contamination is expected to be low and reach PRGs within 150 yr	Reduction through natural attenuation of radionuclides	No short-term worker risk as contaminants are 4.3 to 6.1 m (14 to 20 ft) deep (estimated); short-term ecological impacts are not expected because contaminants are low and at or below the average rooting/animal intrusion depth	Readily implementable	$405
UPR-200-E-9	Very small site; received only about 41 m³ of effluent; not expected to impact groundwater; contaminant concentrations are	Complies with ARARs because human health, ecological, and groundwater protection requirements are assumed to be met	Contamination is expected to be low and reach PRGs within 150 yr	Reduction through natural attenuation of radionuclides	No short-term worker risk as contaminants are 3 m (10 ft) deep; short-term ecological impacts are not expected because	Readily implementable	$406

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
	expected to be low and to reach PRGs through natural attenuation within 150 yr	through the use of existing soil cover and institutional controls; PRGs are met within the 150-yr institutional control period			contaminants are low and at or below the average rooting/animal intrusion depth		
Representative Site							
216-T-26 Crib	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$686
Waste Site Analogous to 216-T-26 Crib							
216-T-18 Crib	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$686
Representative Site							
216-B-5 Injection/ Reverse Well	Groundwater monitoring in the area does not indicate continued mobilization to the water table. The water table in the area has receded, so impacts from seasonal fluctuations in the water table are not	The groundwater protection ARARs for the 216-B-5 and the 216-T-3 Injection/ Reverse Wells under this alternative are not met	Contaminant concentrations are high in the groundwater and will remain elevated past 150 yr; institutional controls may not be protective	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$914

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
	expected		beyond 150 yr; groundwater is not protected				
Waste Site Analogous to 216-B-5 Injection/Reverse Well							
216-T-3 Injection/ Reverse Well	Groundwater monitoring in the area does not indicate continued mobilization to the water table. The water table in the area has receded, so impacts from seasonal fluctuations in the water table are not expected	The groundwater protection ARARs for the 216-B-5 and the 216-T-3 Injection/ Reverse Wells under this alternative are not met	Contaminant concentrations are high in the groundwater and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$914
Representative Site							
216-B-7A & 216-B-7B Cribs	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks expected, contaminants are within 0 to 4.6 m (0-15 ft) bgs	Readily implementable	$683
Waste Sites Analogous to 216-B-7A Crib							
216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs; 216-T-5 Trench; and 200-E-45 Sampling Shaft	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks expected, contaminants are within 0 to 4.6 m (0-15 ft) bgs	Readily implementable	$11,568

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
UPR-200-E-7	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$412
241-B-361 and 241-T-361 Settling Tanks	Sludge poses greatest risk as tanks are not thought to have leaked; after sludge removal, only minimal contamination is expected; remaining contamination is anticipated to reach PRGs within 150 yr	Complies with ARARs by removal of sludge; complies with disposal requirements	After sludge is removed, only minimal risk remains; no anticipated risk to groundwater	Reduction through natural attenuation of radionuclides; sludge would be treated as required to meet waste acceptance criteria	Short-term risks to workers are anticipated to be high for removal of the sludge; no short-term risks associated with implementation of Alternative 2; minimal short-term impacts to vegetation and wildlife associated with sludge removal	Readily implementable	$13,722
Representative Site							
216-B-38 Trench	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks expected, contaminants are within 0 to 4.6 m (0-15 ft) bgs	Readily implementable	$3,718
Waste Sites Analogous to 216-B-38 Trench							
216-B-35 through 216-B-37, 216-B-39	Not protective because contaminants remain above	Does not comply	Contaminant concentrations are high and will remain	Reduction through natural attenuation of	No short-term risks to workers; ecological risks expected,	Readily implementable	Included in 216-B-38 Crib

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
through 216-B-41 Trenches	PRGs after 150 yr		elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	radionuclides	contaminants are within 0 to 4.6 m (0-15 ft) bgs		
216-T-14 through 216-T-17 Cribs, 216-T-21 through 216-T-25 Trenches	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks expected, contaminants are within 0 to 4.6 m (0-15 ft) bgs	Readily implementable	$3,774
Representative Site							
216-B-57 Crib	Site is covered with the Hanford Barrier. This barrier breaks the potential exposure pathways to receptors and limits both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Hanford Barrier is protective to 1,000 yr. PRGs for this site are reached in approximately 330 yrs.	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks; site has Hanford Barrier	Readily implementable	$702
Waste Sites Analogous to 216-B-57 Crib							
216-B-50 Crib, 216-B-11A & 216-B-11B French Drains, 216-B-62 Crib, 216-C-6 Crib, 216-S-9 Crib, and 216-S-21 Crib	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks expected; contaminants are greater than 4.6 m (15 ft) bgs	Readily implementable	$4,202

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
UPR-200-W-108 and UPR-200-W-109						Readily implementable	$409
Representative Site							
216-B-58 Trench	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks may be expected if contaminants are less than 4.6 m (15 ft) bgs	Readily implementable	$695
Waste Sites Analogous to 216-B-58 Trench							
216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	Not protective because contaminants remain above PRGs after 150 yr	Does not comply	Contaminant concentrations are high and will remain elevated past 150 yr; institutional controls may not be protective beyond 150 yr; groundwater is not protected	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks may be expected if contaminants are less than 4.6 m (15 ft) bgs	Readily implementable	$2060

ARAR = applicable or relevant and appropriate requirement. PRG = preliminary remediation goal.

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Representative Site							
216-B-46 Crib	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 935 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 220 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-B-57 Crib. The large area needed to excavate the site would undermine the 216-B-57 Crib cap. In addition, over 457,000 yd^3 would be disposed of at ERDF for all the cribs in this site group.	$399,703
Analogous Sites with Characterization Data							
216-B-43 through 216-B-45, 216-B-47 through 216-B-49 Cribs	Protective because contaminants are removed to meet PRGs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 935 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 220 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-B-57 Crib. The large area needed to excavate the site would undermine the 216-B-57 Crib cap.	Included in the 216-B-46 Crib costs. These sites would be remediated as a group
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs and 216-B-20 through 216-B-	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology,	Contaminants are moved to a less mobile environment. Reduction through natural	High short-term risks to workers; dose to workers estimated to be 935 rem, ecological risks not expected	Excavation to 220 ft is necessary to remove contaminants to PRGs. A large area is needed to excavate the site.	$3,236,073

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
34, 216-B-42, and 216-B-52 Trenches			with little chance of failure	attenuation of radionuclides	because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	In addition, over 6.9 million yd^3 would be disposed of at ERDF for all the trenches in this site group.	
216-BY-201 Settling Tank and 200-E-14 Siphon Tank	Sludge poses greatest risk as tanks are not thought to have leaked; after sludge removal, only minimal contamination is expected; remaining contamination is anticipated to reach PRGs within 150 yr.	Complies with ARARs by removal of sludge; complies with disposal requirements	After sludge is removed, only minimal risk remains; no anticipated risk to groundwater	Reduction through natural attenuation of radionuclides; sludge would be treated as required to meet waste acceptance criteria	Short-term risks to workers are anticipated to be high for removal of the sludge; Short-term impacts to vegetation and wildlife associated with sludge and tank removal	Readily implementable	$12,976
200-E-114 Pipeline	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Removal of the pipeline would be a permanent remedy	Reduces through natural attenuation of radionuclides	Short-term worker risk as contaminants are 2 to 3 m (7 to 10 ft) deep; short-term ecological impacts because of excavation of pipeline.	Readily implementable	$59,579
216-B-51 French Drain	Excavation of contaminants provide overall protection of human health and environment	Complies with ARARs by removing contaminants	Removal is effective in the long term	Reduction through natural attenuation of radionuclides	Short-term worker risk is low due to volume of waste received short-term ecological impacts are expected because of excavation of soils.	Readily implementable	$150,388
UPR-200-E-9	Excavation of contaminants provide overall protection of human health and environment	Complies with ARARs by removing contaminants	Removal is effective in the long term	Reduction through natural attenuation of radionuclides	Short-term worker risk is low due to volume of waste received short-term ecological impacts are expected because of excavation of	Readily implementable	$227

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
					soils.		
Representative Site							
216-T-26 Crib	Protective because contaminants are removed to meet PRGs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through *natural* attenuation of radionuclides	Moderate short-term risks to workers; dose to workers estimated to be 0.54 rem, ecological risks *not expected* because contaminants are removed. Higher possibility of impacting biological and/or cultural resources exists because of the large excavation area	Excavation to 200 ft is necessary to remove contaminants to PRGs. Excavation at this site is *impractical* because of the location of the 216-T-27 and 216-T-28 Cribs. Excavation activities would need to be coordinated with the remediation of the adjacent cribs.	$39,576
Waste Site Analogous to 216-T-26 Crib							
216-T-18 Crib	Protective because contaminants are removed to meet PRGs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers; dose to workers estimated to be 0.54 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources exists because of the large excavation area	Excavation to 200 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-T-27 and 216-T-28 Cribs. Excavation activities would need to be coordinated with the remediation of the adjacent cribs.	$39,576
Representative Site							
216-B-5 Injection/ Reverse Well	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be over 6 rem, ecological risks not expected because contaminants are removed. Higher	Excavation to 285 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because over 4 million yd^3 of soil needs to be	$102,830

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
					possibility of impacting biological and/or cultural resources because of the large excavation area	removed to remove 208 yd³ of contaminated soil.	
Waste Site Analogous to 216-B-5 Injection/Reverse Well							
216-T-3 Injection/ Reverse Well	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be over 6 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 285 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because over 4 million yd³ of soil needs to be removed to remove 208 yd³ of contaminated soil.	$49,552
Representative Site							
216-B-7A & 216-B-7B Cribs	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be approximately 6 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 222 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 241-B Tank Farm. In addition, over 1.9 million yd³ would removed to remove 1,481 yd³ of contaminated soil.	$244,003
Waste Sites Analogous to 216-B-7A Crib							
216-B-8, 216-B-9, 216-T-6, 216-T-7,	Protective because contaminants are removed	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs.	Contaminants are moved to a less mobile environment.	High short-term risks to workers; dose to workers estimated to be	Excavation to 222 feet is necessary to remove contaminants to	$1,684,815

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
and 216-T-32 Cribs; 216-T-5 Trench; and 200-E-45 Sampling Shaft	to meet PRGs.		Excavation proven technology, with little chance of failure	Reduction through natural attenuation of radionuclides	approximately 6 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	PRGs. Excavation at this site is impractical due to the location of the 241-B Tank Farm. In addition, over 1.9 million cubic yards would be removed to remove 1,481 cubic yards of contaminated soil.	
UPR-200-E-7	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers; ecological risks not expected because contaminants are removed.	Readily implementable	$265
241-B-361 and 241-T-361 Settling Tanks	Sludge poses greatest risk as tanks are not thought to have leaked; after sludge removal, only minimal contamination is expected; remaining	Complies with ARARs by removal of sludge; complies with disposal requirements	After sludge is removed, only minimal risk remains; no anticipated risk to groundwater	Reduction through natural attenuation of radionuclides; sludge would be treated as required to meet waste acceptance criteria	Short-term risks to workers are anticipated to be high for removal of the sludge; short-term impacts to vegetation and wildlife associated with sludge and tank removal	Readily implementable	$14,156
Representative Site							
216-B-38 Trench	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 1560 rem; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation	Excavation to 220 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-B-57 Crib. The large area needed to excavate the site would undermine the 216-B-57 Crib cap. In addition,	$1,036,246

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
					area	over 1.3 million yd³ would be disposed of at ERDF for all the cribs adjacent to this crib.	
Waste Sites Analogous to 216-B-38 Trench							
216-B-35 through 216-B-37, 216-B-39 through 216-B-41 Trenches	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be1560 rem; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 220 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-B-57 Crib. The large area needed to excavate the site would undermine the 216-B-57 Crib cap. In addition, over 1.3 million yd³ would be disposed of at ERDF for all the cribs adjacent to this crib.	Included in 216-B-38 Trench cost. These sites would be remediated as a group
216-T-14 through 216-T-17, 216-T-21 through 216-T-25 Trenches	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 1560 rem; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Excavation to 220 ft is necessary to remove contaminants to PRGs. Excavation at this site is impractical because of the location of the 216-B-57 Crib. The large area needed to excavate the site would undermine the 216-B-57 Crib cap. In addition, over 1.3 million yd³ would be disposed of at ERDF for all the cribs adjacent to this crib.	$1,458,056

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Representative Site							
216-B-57 Crib	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site	N/A. Barrier currently in place for this waste site
Waste Sites Analogous to 216-B-57 Crib							
216-B-50 Crib, 216-B-11A & 216-B-11B French Drains, 216-B-62 Crib, 216-C-6 Crib, 216-S-9 Crib, and 216-S-21 Crib	*Protective because contaminants are removed to meet PRGs.*	*Complies with ARARs by removing contaminants*	*Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure*	*Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides*	*High short-term risks to workers; dose to workers estimated to be 10 rem; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area*	*Excavation to 177 ft is necessary to remove contaminants to PRGs.*	*$132,012*
UPR-200-W-108 and UPR-200-W-109	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Short-term risks to workers is low given the volume of the spill ecological risks not expected because contaminants are removed.	Readily implementable.	$169
Representative Site							
216-B-58 Trench	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Short-term risks to workers is moderate; dose to workers estimated to be approximately 0.04 rem; ecological risks not expected because contaminants are removed.	Readily implementable contaminants approximately 7.3 m (24 ft) bgs	$1,531

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Waste Sites Analogous to 216-B-58 Trench							
216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Short-term risks to workers is moderate; dose to workers estimated to be approximately 0.04 rem; ecological risks not expected because contaminants are removed.	Readily implementable contaminants approximately 7.3 m (24 ft) bgs	$4,820

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.
PRG = preliminary remediation goal.

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Representative Site							
216-B-46 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 410 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$5,548
Analogous Sites with Characterization Data							
216-B-43 through 216-B-45, 216-B-47 through 216-B-49	This alternative would break potential exposure pathways to receptors	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as	Readily implementable; source of fine grain capping materials has	Included in 216-B-46 Crib cost. These sites would be remediated

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementa-bility	Cost ($1000)
Cribs	through placement of a surface barrier to limit both infiltration and intrusion.		reached in approximately 410 yrs.		the final layer	not been identified.	as a group
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs and 216-B-20 through 216-B-34, 216-B-42, and 216-B-52 Trenches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 410 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$84,427
216-BY-201 Settling Tank and 200-E-14 Siphon Tank	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with Complies with ARARs because the barrier is in place		Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$14,654
200-E-114 Pipeline	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 410 yrs.	Reduces through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$5,492
216-B-51 French Drain	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$649

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	*Threshold Criteria* Overall Protection of Human Health and the Environment	*Threshold Criteria* Compliance with ARARs	*Balancing Criteria* Long-Term Effectiveness and Permanence	*Balancing Criteria* Reduction of Toxicity, Mobility, or Volume Through Treatment	*Balancing Criteria* Short-Term Effectiveness	*Balancing Criteria* Implementability	*Balancing Criteria* Cost ($1000)
	limit both infiltration and intrusion.		410 yrs.				
UPR-200-E-9	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 410 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$653
Representative Site							
216-T-26 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 330 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,126
Waste Site Analogous to 216-T-26 Crib							
216-T-18 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 330 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,126
Representative Site							
216-B-5 Injection/ Reverse Well	Protective because This alternative would break potential exposure pathways to	Complies with ARARs because the barrier is in place		Contaminants are reduced through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as	Readily implementable; source of fine grain capping materials has not been	$1,627

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
	receptors through placement of a surface barrier to limit both infiltration and intrusion.				the final layer	identified.	
Waste Site Analogous to 216-B-5 Injection/Reverse Well							
216-T-3 Injection/ Reverse Well	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place		Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$1,627
Representative Site							
216-B-7A & 216-B-7B Cribs	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Hanford-type barrier is protective to 1000 yr. PRGs for this site are reached in approximately 380 yrs, for the short lived radionuclides With TRU waste present this barrier is protective to 1000 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,168
Waste Sites Analogous to 216-B-7A Crib							
216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs; 216-T-5 Trench; and 200-E-45 Sampling	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and	Complies with ARARs because the barrier is in place	Hanford type barrier is protective to 1000 yr. PRGs for this site are reached in approximately 380 yrs, for the short lived radionuclides With TRU	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$26,918

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($1000)
Shaft	intrusion.		waste present this barrier is protective to 1000 yr.				
UPR-200-E-7	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Hanford type barrier is protective to 1000 yr. PRGs for this site are reached in approximately 380 yrs, for the short lived radionuclides With TRU waste present this barrier is protective to 1000 yrs	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$664
241-B-361 and 241-T-361 Settling Tanks	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place		Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$15,986
Representative Site							
216-B-38 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 400 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$11,136
Waste Sites Analogous to 216-B-38 Trench							
216-B-35 through 216-B-37, 216-B-39	This alternative would break potential exposure	Complies with ARARs because the barrier is in	Modified RCRA C type barrier is protective to	Reduction through natural attenuation of	Limited short-term risks to workers; no ecological risks expected; site will	Readily implementable; source of fine grain capping	Included in 216-B-38 Trench cost. These sites

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost ($1000)**
through 216-B-41 Trenches	pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	place	500 yr. PRGs for this site are reached in approximately 400 yrs.	radionuclides	be capped and clean soil placed as the final layer.	materials has not been identified.	would be remediated as a group
216-T-14 through 216-T-17, 216-T-21 through 216-T-25 Trenches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 400 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$11,302
Representative Site							
216-B-57 Crib	Barrier currently in place for this waste site	Barrier currently in place for this waste site	Barrier currently in place for this waste site	Reduction through natural attenuation of radionuclides	Barrier currently in place for this waste site	Barrier currently in place for this waste site	N/A
Waste Sites Analogous to 216-B-57 Crib							
216-B-50 Crib, 216-B-11A & 216-B-11B French Drains, 216-B-62 Crib, 216-C-6 Crib, 216-S-9 Crib, and 216-S-21 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 330 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$9,437
UPR-200-W-108 and UPR-200-W-109	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both	Complies with ARARs because the barrier is in place s	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 330 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$708

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost ($1000)**
	infiltration and intrusion.						
Representative Site							
216-B-58 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 283 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,703
Waste Sites Analogous to 216-B-58 Trench							
216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Modified RCRA C type barrier is protective to 500 yr. PRGs for this site are reached in approximately 283 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$5,780

ARAR = applicable or relevant and appropriate requirement.
PRG = preliminary remediation goal.
RCRA = *Resource Conservation and Recovery Act of 1976.*

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost ($0000)**
Representative Site							
216-B-46 Crib	This alternative would break potential	Complies with ARARs	This alternative is protective of human health and	Reduction through natural	High short-term risks to workers; dose to workers	Readily implementable; source of fine	$21,793

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($0000)
	exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	because the barrier is in place	the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	attenuation of radionuclides	estimated to be 935 rem, ecological risks are not expected because contaminants are removed.	grain capping materials has not been identified.	
Analogous Sites with Characterization Data							
216-B-43 through 216-B-45, 216-B-47 through 216-B-49 Cribs	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 935 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	Included in 216-B-46 Crib cost. These sites would be remediated as a group
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs and 216-B-20 through 216-B-34, 216-B-42, and 216-B-52 Trenches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be over 935 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$331,966
216-BY-201 Settling	NA.	NA	NA	NA	NA	NA	NA

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($0000)
Tank and 200-E-14 Siphon Tank							
200-E-114 Pipeline	NA	NA	NA	NA	NA	NA	NA
216-B-51 French Drain	NA	NA	NA	NA	NA	NA	NA
UPR-200-E-9	NA	NA	NA	NA	NA	NA	NA
Representative Site							
216-T-26 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers; dose to workers estimated to be 0.54 rem; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources exists because of the large excavation area	Readily implementable; source of fine grain capping materials has not been identified.	$2,070
Waste Site Analogous to 216-T-26 Crib							
216-T-18 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be approximately 0.54 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$2,070

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implemen-tability	Cost ($0000)
Representative Site							
216-B-5 Injection / Reverse Well	NA	NA	NA	NA	NA	NA	NA
Waste Site Analogous to 216-B-5 Injection/Reverse Well							
216-T-3 Injection / Reverse Well	NA	NA	NA	NA	NA	NA	NA
Representative Site							
216-B-7A & 216-B-7B Cribs	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 6 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$1,668
Waste Sites Analogous to 216-B-7A Crib							
216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs; 216-T-5 Trench; and 200-E-45 Sampling Shaft	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 6 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$65,277

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implemen-tability	Cost ($0000)
UPR-200-E-7	NA	NA	NA	NA	NA	NA	NA
241-B-361 and 241-T-361 Settling Tanks	NA	NA	NA	NA	NA	NA	NA
Representative Site							
216-B-38 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 1560 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$75,049
Waste Sites Analogous to 216-B-38 Trench							
216-B-35 through 216-B-37, 216-B-39 through 216-B-41 Trenches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 1560 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	Included in 216-B-38 Trench cost. These sites would be remediated as a group
216-T-14 through 216-T-17, 216-T-21 through	This alternative would break potential exposure pathways to receptors	Complies with ARARs because the barrier is in	This alternative is protective of human health and the environment by removing a portion of the	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be1560 rem; ecological risks not expected	Readily implementable; source of fine grain capping materials has not been	$77,450

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000)
216-T-25 Trenches	through placement of a surface barrier to limit both infiltration and intrusion.	place	contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.		because contaminants are removed	identified.	
Representative Site							
216-B-57 Crib	Barrier currently in place for this waste site	Barrier currently in place for this waste site	Barrier currently in place for this waste site	Reduction through natural attenuation of radionuclides	Barrier currently in place for this waste site	Barrier currently in place for this waste site	N/A
Waste Sites Analogous to 216-B-57 Crib							
216-B-50 Crib, 216-B-11A & 216-B-11B French Drains, 216-B-62 Crib, 216-C-6 Crib, 216-S-9 Crib, and 216-S-21 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be approximately 10 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	$37,408
UPR-200-W-108 and UPR-200-W-109	NA	NA	NA	NA	NA	NA	NA
Representative Site							
216-B-58 Trench	This alternative would break potential exposure pathways to receptors through	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be approximately 0.04 rem; ecological risks not expected	Readily implementable; source of fine grain capping materials has not been	NA

Table 6-4. Detailed Analysis Summary for Alternative 5 –Partial Removal, Treatment, and Disposal with Capping. (7 Pages)

Waste Site	Threshold Criteria: Overall Protection of Human Health and the Environment	Threshold Criteria: Compliance with ARARs	Balancing Criteria: Long-Term Effectiveness and Permanence	Balancing Criteria: Reduction of Toxicity, Mobility, or Volume Through Treatment	Balancing Criteria: Short-Term Effectiveness	Balancing Criteria: Implementability	Balancing Criteria: Cost ($0000)
	placement of a surface barrier to limit both infiltration and intrusion.		the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.		because contaminants are removed	identified.	
Waste Sites Analogous to 216-B-58 Trench							
216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	This alternative is protective of human health and the environment by removing a portion of the contaminants in the soil and breaking exposure pathways. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be approximately 0.04 rem; ecological risks not expected because contaminants are removed.	Readily implementable; source of fine grain capping materials has not been identified.	NA

ARAR = applicable or relevant and appropriate requirement.
PRG = preliminary remediation goal.

Table 6-5. Summary of Baseline Dose and Risk to a Potential Intruder at 150 Years[a].

Site	Intruder Dose (mrem/yr)	Intruder Risk
216-B-46 Crib	137	2.2 E-03
216-T-26 Crib	26	3.8 E-03
216-B-58 Trench	7.7	1.3 E-04
216-B-43 Crib	1355	2.1 E-02
216-B-44 Crib	1164	1.8 E-02
216-B-45 Crib	2451	3.9 E-02
216-B-47 Crib	4218	6.5 E-02
216-B-48 Crib	4664	7.8 E-02
216-B-49 Crib	624	4.2 E-02
216-B-26 Trench	270	4.4 E-03
216-B-7A&B	238	2.7 E-03
216-B-38 Trench	109	1.8 E-03
216-B-57-Crib	35	5.7 E-04
216-B-58 Trench	7.7	1.3 E-04

[a]Dose and risk are baseline values assuming the current concentrations decay for 150 yr, then the contaminated soil is removed and used by the intruder in a garden plot. Details are provided in Appendix E.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the five remedial alternatives for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites to identify their relative advantages and disadvantages. This comparison is based on the seven CERCLA evaluation criteria discussed in Chapter 6.0. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and associated analogous waste sites. These remedial alternatives are as follows:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Capping.
- Alternative 5 – Partial Removal, Treatment, and Disposal with Capping.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would fail to provide overall protection of human health and the environment, because contaminants at concentrations above the PRGs would remain on site with no actions to restrict intrusion or protect groundwater. No waste sites in these OUs are expected to be remediated under the no-action alternative.

Alternative 2 would not provide overall protection of human health and the environment for the majority of the waste sites in these OUs. However, differences among representative sites and their analogous sites with regard to the process history, site size, or potential remedial action require further explanation. An example is the 216-B-57 Crib, where the existing Hanford Barrier provides adequate protection for human health, the environment, and the groundwater. The Hanford Barrier is designed to be protective for 1,000 yr; therefore, this crib qualifies under Alternative 2. Additional sites identified include the 216-B-51 French Drain, which received the same type of process waste as the 216-B-46 Crib; however, the quantity of waste received was three orders of magnitude less than the representative site. The 216-B-46 Crib site received 6,700 m^3 (1.77 million gal) of process waste, while the 216-B-51 French Drain received 1 m^3 (275 gal). Given this large volume difference and the nature of the contaminants in the 216-B-46 Crib, the 216-B-51 French Drain site should meet the criteria for overall protectiveness of human health and the environment.

Four tanks, the 216-BY-201 Settling Tank, 200-E-14 Siphon Tank, 241-B-361 Settling Tank, and 241-T-361 Settling Tank all have similar remedial actions. The postulated remedial action would remove the sludge from the tanks, fill the void space with a structural fill to prevent subsidence, and monitor the site.

Alternative 3 is considered protective of long-term human health and the environment. However, deep contamination exists at the majority of the sites. Considerable resources would be expended to remove the deep contamination. These resources include land to stockpile uncontaminated overburden, disposal space at the on-site landfill, workers due to the high dose rate, and in some cases, deep excavations would extend into existing structures and operating facilities (e.g., tank farms). Furthermore, Alternative 3 would expose workers to high doses of contamination. Exceptions are the 216-T-26 Crib analogous sites and the 216-B-58 Trench analogous sites, where the worker dose is approximately 0.54 and 0.04 rem, respectively. Doses at the remaining sites range from 6 rem to over 1,500 rem, depending on the types and concentrations of contaminants at these waste sites.

Alternative 4 is considered protective of human health and the environment, because it would break potential exposure pathways to receptors through placement of a surface barrier and implementation of institutional controls. The barrier also would provide groundwater protection by limiting and controlling infiltration. Caps would be designed commensurate with site contaminant conditions, and institution controls would be used at capped sites to augment protectiveness until the PRGs are achieved through natural attenuation. The site would incorporate monitoring and inspections of barrier performance and natural attenuation to aid in the evaluation of cap performance. The cap would provide additional intrusion protection past the 150-year institutional controls period and infiltration control to protect groundwater. The area would be maintained for industrial land use.

Alternative 4 is protective, provided that monitoring (e.g., monitored natural attenuation, barrier performance, groundwater protection) is implemented where groundwater protection criteria are exceeded. Alternatives 2, 4, and 5 would leave contamination on site and would require institutional controls to be protective over the necessary timeframe. Alternative 3 would remove contaminants above PRGs.

Alternative 5 is considered protective of human health and the environment, because it would break potential exposure pathways to receptors through placement of a surface barrier and institutional controls and would provide groundwater protection by limiting and controlling infiltration. Caps would be designed commensurate with site contaminant conditions, and institution controls would be used at capped sites to augment protectiveness until the PRGs are achieved through natural attenuation. The site would incorporate monitoring and inspections of barrier performance and natural attenuation to aid in the evaluation of cap performance. The cap would provide additional intrusion protection past the 150-year institutional controls period and infiltration control to protect groundwater. The area would be maintained for industrial land use.

Alternative 5 is protective, if monitoring (e.g., monitored natural attenuation, barrier performance, groundwater protection) is implemented where groundwater protection criteria are exceeded. As mentioned above in Alternative 3, remediation workers would be exposed to high doses of contaminants during the remediation with the exception of the 216-T-26 Crib site.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Alternative 1 does not comply with ARARs, because no sites within the 200-TW-1, 200-TW-2, and 200-PW-5 OUs meet the criteria under this alternative.

Alternative 2 generally does not comply with the ARARs because it is not protective of human health and the environment for most of the representative sites; however, this alternative would comply with all ARARs for the 216-B-57 Crib, a site with a small amount of contamination, which is located near the surface. The Hanford Prototype Barrier already is installed over this site; no additional cap is required at the site. Maintenance and the design of the cap provide compliance with ARARs in the long-term. The ARARs may be met under Alternative 2 for the 216-E-114 Pipeline. This is a 5 cm (2-in.) steel pipeline that runs from the BY and C Tank Farms to the 200-E-14 Siphon Tank and the 216-B-14 through 216-B-19 Cribs. The pipeline is buried 2.1 to 3 m (7 to 10 ft) deep and is almost 4.8 km (3 mi) long. The only evidence of leakage was a small amount near the tank farms source. Because of the small diameter, the steel construction, and basic/neutral waste stream, significant leaks along the pipeline are unlikely. Confirmatory sampling is required before this alternative is implemented.

The ARARs for 216-B-5 and 216-T-3 Injection/Reverse Wells would not be met under Alternative 2 without a wavier. Contaminants remain in deep in the vadose zone potentially above PRGs. The contaminants would not be effectively addressed by a cap because they are currently close to the water table. However, groundwater monitoring at the 216-B-5 Injection/Reverse Well indicates declining groundwater concentrations and the contaminants in the vadose are not generally very mobile.

Alternative 3 complies with most of the ARARs by removal of contamination to the PRGs. Worker protection ARARs may be exceeded, however, without adequate worker protections, due to the high concentrations of contaminants associated with the waste sites.

Alternative 4 complies with the ARARs by breaking exposure pathways. Where contaminants remain at depths that exceed the groundwater protection criterion, vadose zone or groundwater monitoring will be required to show protectiveness of groundwater.

Alternative 5 complies with most of the ARARs by breaking exposure pathways through removal of shallow contaminants followed by a cap to protect the groundwater from deeper contaminants. Where contaminants remain at depths that exceed the groundwater protection criterion, vadose zone or groundwater monitoring will be required to show protectiveness of groundwater. Worker protection ARARs may be exceeded, however, without adequate worker protections, due to the high concentrations of contaminants associated with the waste sites.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 1 is not effective in the long term because waste remains in place without any protections. In contrast, the other three alternatives would be effective and protective in the long term, but to different levels.

Alternative 2 would not be an effective and permanent remedial action in the long term for most of the waste sites in these OUs because of the extended period of time that the contaminants would remain on site. Alternative 2 is effective for the 216-B-57 Crib in the long term because of the Hanford Barrier that is in place at this site. Alternative 2 is also considered effective for the 241-B-361 and 241-T-361 Settling Tanks, the 216-BY-201 Settling Tank, and the 200-E-14 Siphon Tank because most of the risk is associated with the sludge, which will be removed. Alternative 2 is also considered protective at the 216-B-51 French Drain and the 200-E-114 Pipeline. The French drain received only a minor waste volume and the 200-E-114 Pipeline is only 5 cm (2 in.) in diameter with two small leak locations. A portion of the pipeline will be removed to provide additional data for this waste site.

Alternative 3 would provide the highest degree of effectiveness in the long term. With Alternative 3, contaminant concentrations above the PRGs would be removed. The removed contaminated material would be disposed of at the ERDF or the Waste Isolation Pilot Plant, if some waste were determined to contain transuranic constituents at levels of concern (e.g., the 216-B-7A Crib).

Alternative 4 provides the highest degree of overall effectiveness in the long term for the majority of the sites, because it addresses all the potential pathways: direct exposure by humans and biota and protection of groundwater. Alternative 4 would be protective in the long term by breaking the exposure pathways and reducing the infiltration through the contaminated zone. Long-term effectiveness depends on the design and maintenance of the barrier and associated monitoring (e.g., barrier performance, natural attenuation). For those waste sites where deeper contamination is identified as exceeding groundwater protection criteria, Alternative 4 would require additional monitoring (e.g., groundwater protection). Therefore, long-term restrictions would apply.

Alternative 5 would be protective in the long term by breaking the exposure pathways and reducing the infiltration through the remaining contaminated zone. Long-term effectiveness depends on the design and maintenance of the barrier and associated monitoring (e.g., barrier performance, natural attenuation). For those waste sites where deeper contamination is identified as exceeding groundwater protection criteria, Alternative 5 would require additional monitoring (e.g., groundwater protection). Therefore, long-term restrictions would apply.

7.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

None of the alternatives include treatment and, therefore, they do not reduce the toxicity, mobility, or volume of the contaminants through treatment. All of the alternatives incorporate natural attenuation in the form of radiological decay, which ultimately results in reduced toxicity and volume. Alternatives 3, 4, and 5 provide an additional perceived reduction because they include a physical action that places the contaminants in a more managed environment, thereby reducing the forces (e.g., infiltration) that drive the contaminants toward groundwater.

7.5 SHORT-TERM EFFECTIVENESS

Alternative 1 would be effective for workers in the short term, because it does not involve any remedial actions; however, at some sites with contaminants in the active rooting zone or burrowing animal zone, biota could be exposed to unacceptable concentrations. Alternatives 2 and 4 would be significantly more effective in the short term than Alternatives 3 and 5, predominantly because of lower risk to remediation workers.

Alternative 3 would generate large volumes of contaminated soil and debris, which would create a potential for short-term worker impacts during excavation and transportation of the excavated materials. In addition, contaminant concentrations are high enough at these waste sites to result in significant doses to workers during the excavation of soils. Disposal of all the contaminated soils at the onsite disposal facility (ERDF) would require approximately 7.65 million m^3 (10 million yd^3) of space. Current available volume at ERDF is approximately 5.85 m^3 (7.65 million yd^3). Exceptions to this would be the 216-B58 Trench, its analogous waste sites, and unplanned release site, where the contamination levels result in much lower worker risk.

Risks to workers from potential exposure to contaminated soil and fugitive dust would be significantly greater in the short term with Alternative 3 than with Alternative 4. However, for some of the sites, Alternative 4 also would entail aboveground structure demolition, transportation of contaminated debris, and filling of subsurface void spaces. Short-term impacts to vegetation and wildlife could be significant for Alternative 3 because of disturbances at the waste site associated with soil removal and disturbances at the borrow sites for backfill. The actual short-term impacts to vegetation and wildlife will vary from site to site but are considerable because of the large disturbed areas. Alternatives 3, 4, and 5 have the highest probability of affecting cultural resources in the short term because of the large land-area disturbance and the need for large volumes of capping or backfill material from borrow areas.

Alternative 4 would pose less risk to workers than Alternative 3 and 5, because the "removal, treatment, and disposal" component of the capping alternative is limited to aboveground structures and would affect only a few of the waste sites. Limited waste would be handled, so the risks to remediation workers associated with this option would be lower than those related to the large-scale excavation, characterization, transportation, and disposal of waste with the remove-and-dispose alternative. Additional short-term risk to workers would be expected from the transportation of materials and construction of the caps, but these activities would pose less short-term risk than activities associated with Alternatives 3 and 5. Furthermore, because of the smaller land area affected and the shorter duration to implement the capping alternative, Alternative 4 would be more effective than Alternative 3 in the short term with respect to reduced impact on potential cultural and ecological resources. If barriers are required for the waste sites, the need for fine-grained materials for cap construction becomes a concern. These materials are limited at the Hanford Site and tend to be located in potentially ecologically sensitive areas. Alternative 4 would reach RAOs more quickly than Alternative 3 and 5.

Alternative 5 would present approximately the same risk to workers as Alternative 3 because of the high dose received during the removal operation. The construction risk to workers would be less than Alternative 3, mainly because of time to implement. The capping activities present the same level of risk as Alternative 4, but the overall cumulative risk for Alternative 5 would be greater than for Alternative 4.

7.6 IMPLEMENTABILITY

Alternative 1 would be easily implemented, because no action is performed.

Alternative 2 is currently in use for all of the waste sites. The waste sites are in surveillance and monitoring programs and are posted with signs and/or the area is fenced. Access to the waste sites also is controlled through Hanford Site access requirements, an excavation permit program, and a radiation work area permit program. The addition of monitoring wells or boreholes is easily implementable.

Alternative 3 would be the most complicated to implement in the near term, because of the difficulties and safety requirements associated with the excavation, transportation, and disposal of soil and debris. This remedy is not considered implementable at the following sites:

- 216-B-43 through 216-B-50 Cribs because of interferences with the existing Hanford Barrier
- 216-B-7A Crib because of the excavation extending into the B Tank Farm
- 216-B-7B Crib because of the excavation extending into the B Tank Farm
- 216-T-5 Trench because of the excavation extending into the T Tank Farm
- 216-T-7 Crib because of the excavation extending into the T Tank Farm
- 216-T-32 Cribs because of the excavation extending into the T Tank Farm
- 216-B-35 through 216-B-42 Trenches because of interferences with the existing Hanford Barrier
- 216-T-14 through 216-T 17 Trenches because of the excavation extending into the T Tank Farm
- 216-C-6 Crib because of its close proximity to an unnumbered building.

Alternative 3 would involve excavation and segregation of pipes, concrete structures, and other solid waste. The volume of waste generated by this alternative would exceed the current capacity at the ERDF.

Alternative 4 is implementable. A barrier has been implemented at the Hanford Site; other types of barriers have been regulatory approved and implemented at other western arid sites and are easy to construction and maintain. Facilities and infrastructure near the waste sites could influence the implementability of a surface barrier option at a particular site.

Alternative 5 is a combination of Alternatives 3 and 4 and would be implementable. This alternative would excavate the waste sites to depths reachable with standard earth moving equipment. Some of the equipment, notably the excavation equipment, would require modification to protect workers and work in the high dose areas. The cap would be designed and constructed to limit infiltration, an activity that is readily implementable. Worker risk is the biggest hindrance to implementability of this alternative.

7.7 COST

The costs to implement the alternatives are presented in Chapter 6.0 and Appendix D. Alternative 1 has no associated cost but has no additional benefit to human health and the environment over current risks. Alternative 2 generally does not protect human health and the environment; however, Alternative 2 would have the lowest cost because it is minimally invasive and does not include labor-intensive activities. Alternative 3 is the most costly because of the depth of excavation and high contamination levels that will require specialized excavation and waste handling processes. Alternative 4 is generally less expensive than Alternatives 3 and 5. Alternative 4 tends to be the most cost effective because this alternative addresses all the exposure pathways while minimizing worker risk associated with the high contaminant concentrations and the spread of contaminants deep in the vadose zone. Alternatives 3 and 5 meet the overall protectiveness goal but at significantly more cost, in dollars and in dose to workers. Alternative 5 reduces intruder risk and is generally more expensive than Alternative 4 but less expensive than Alternative 3.

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8.0 CONCLUSIONS AND PATH FORWARD

This chapter summarizes the results of the FS and presents the path forward for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites. As described in DOE/RL-98-28, this chapter identifies the preferred alternatives for remediation of the waste sites.

8.1 FEASIBILITY STUDY SUMMARY

Five remedial alternatives were evaluated for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites. These alternatives included the following:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Capping
- Alternative 5 – Partial Removal, Treatment, and Disposal with Capping.

The alternatives were evaluated against the CERCLA criteria; then they were evaluated against each other using the CERCLA criteria. Tables 8-1 through 8-7 identify the preferred alternative for each waste site in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs and provide justification for the preferred alternative selection based on the detailed and comparative analyses presented in Chapters 6.0 and 7.0 of this FS.

8.1.1 Representative Site 216-B-46 Crib and Its Analogous Waste Sites

The 216-B-46 Crib is the representative site for the following waste sites:

- The 216-B-43 through 216-B-45 Cribs and the 216-B-47 through 216-B-49 Cribs (located proximal to the 216-B-46 Crib and commonly referred to as the BY Cribs)
- The 216-B-14 through 216-B-19 Cribs (located in the BC Cribs and Trenches area south of the 200 East Area)
- The 216-B-20 through 216-B-22 Trenches (also located in the BC Cribs and Trenches area)
- The 216-B-23 through 216-B-34 Trenches (also located in the BC Cribs and Trenches area)
- The 216-B-52 Trench (also located in the BC Cribs and Trenches area)

- The 216-B-42 Trench
- The 216-BY-201 Settling Tank and the 200-E-14 Siphon Tank
- The 200-E-114 Pipeline
- Unplanned Release UPR-200-E-9.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-1. The detailed and comparative analyses are provided in Chapters 6.0 and 7.0, respectively.

The preferred alternative for 216-B-46 Crib, the 216-B-14 through 216-B-19 Cribs, the 216-B-20 through 216-B-34 Trenches, 216-B-43 through 216-B-45 Cribs, the 216-B-47 through 216-B-49 Cribs, The 216-B-42 Trench, and the 216-B-52 Trench is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and workers.

The preferred alternative for the 216-BY-201 Settling Tank and the 200-E-14 Siphon Tank is Alternative 4, Capping, because of their proximity to the BY Cribs (216-B-43 through 216-B-49 Cribs) and the BC Cribs, respectively. The sludge will be removed from the tanks, which will eliminate most of the risk associated with the tanks. The 216-BY-201 Settling Tank will be capped because of its location in the footprint of the cap for the 216-B-43 through 216-B-49 Cribs. The 200-E-14 Siphon Tank will be capped because of its location in the footprint of the cap for the BC Cribs (216-B-14 through 216-B-19 Cribs).

The preferred alternative for the 200-E-114 Pipeline is Alternative 2, Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation, because this alternative provides protectiveness for the minor contamination assumed for this waste site. A portion of the pipeline, from the BC Cribs to Route 4 South, will, however, be removed through Alternative 3, Removal, Treatment, and Disposal, to facilitate remedial actions in the BC Cribs and Trenches area and to provide additional data to support the conceptual model for this waste site. If other leak areas are identified in the confirmatory sampling phase, additional removal of the pipeline may be conducted.

The preferred alternative for UPR-200-E-9 is Alternative 3, Removal, Treatment, and Disposal, because this alternative is most protective of human health and the environment at this waste site and is easily implementable with acceptable worker risk.

8.1.2 Representative Site 216-T-26 Crib and Its Analogous Waste Site

The 216-T-26 Crib is the representative site for the 216-T-18 Crib. Based on current conditions, the 216-T-26 Crib exceeds the groundwater protection PRGs for cyanide, nitrate, nitrite, uranium, Tc-99, U-233/234/238, and Pu-239, because elevated concentrations are found throughout the soil column to nearly 200 ft bgs.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-2. The preferred alternative for the 216-T-26 and 216-T-18 Cribs is Alternative 4, Capping, because this alternative is protective of the groundwater, is protective of the workers, is easily implementable, and is cost effective. The 216-T-26 Crib currently is stabilized with two other cribs, the 216-T-27 and 216-T-28 Cribs. One of these cribs is slated for characterization in 2004. The remedial decision and the remediation of the 216-T-26 Crib and the other two nearby cribs will have to be coordinated.

8.1.3 Representative Site 216-B-5 Reverse Well and Its Analogous Waste Site

The 216-B-5 Injection/Reverse Well is the representative site for the 216-T-3 Injection/Reverse Well. A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-3. The preferred alternative for the 216-B-5 and 216-T-3 Injection/Reverse Wells is Alternative 2, Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation, because this alternative is the most implementable for the deep contamination found at these sites and provides protection through groundwater monitoring. The contaminants at the 216-B-5 Injection/Reverse Well generally are immobile and are not likely to continue to impact the groundwater. Groundwater monitoring indicates declining contamination levels; however, the contaminants are near the water table, so groundwater monitoring provides added protection at these waste sites. Treatability testing at the 216-B-5 Injection/Reverse Well indicated that a pump-and-treat system could be used to remove contaminants from the groundwater if contaminants do impact the groundwater. Other technologies evaluated for deep contamination are not effective or implementable and are cost prohibitive (see Chapters 5.0 through 7.0).

8.1.4 Representative Site 216-B-7A Crib and Its Analogous Waste Sites

The 216-B-7A Crib is the representative site for the following waste sites:

- The 216-B-7B, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs
- The 216-T-5 Trench
- The 200-E-45 Sampling Shaft
- The 241-B-361 and 241-T-361 Settling Tanks
- Unplanned Release UPR-200-E-7.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-4. The preferred alternative for 216-B-7A, 216-B-7B, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs; the 216-T-5 Trench; and the 200-E-45 Sampling Shaft is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and workers.

The preferred alternative for the 241-B-361 and 241-T-361 Settling Tanks is Alternative 2, Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation, because this alternative provides protectiveness for the minor contamination assumed for this waste site after removal of the sludge.

The preferred alternative for UPR-200-E-7 is Alternative 3, Removal, Treatment, and Disposal, because this alternative is most protective of human health and the environment, is implementable, and is protective of workers.

8.1.5 Representative Site 216-B-38 Trench and Its Analogous Waste Sites

The 216-B-38 Trench is the representative site for the following waste sites:

- The 216-B-35 through 216-B-37 Trenches and the 216-B-39 through 216-B-41 Trenches
- The 216-T-14 through 216-T-17 Trenches
- The 216-T-21 through 216-T-25 Trenches.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-5. The preferred alternative for the 216-B-35 through 216-B-41 Trenches, the 216-T-14 through 216-T-17 Trenches, and 216-T-21 through 216-T-25 Trenches is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and workers.

8.1.6 Representative Site 216-B-57 Crib and Its Analogous Waste Sites

The 216-B-57 Crib is the representative site for the following waste sites:

- The 216-B-50 Crib (this crib one of the BY Cribs located north of the BY Tank Farm)
- The 216-B-11A and 216-B-11B French Drains
- The 216-B-62 Crib
- The 216-C-6 Crib
- The 216-S-9 Crib
- The 216-S-21 Crib
- UPR-200-W-108
- UPR-200-W-109.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-6. The preferred alternative for the 216-B-57 Crib is Alternative 2, Maintain the Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation, because the existing Hanford Barrier that was constructed over this waste site is most protective of human health and the environment. Alternative 2 would continue the maintenance and monitoring of the existing cap.

The preferred alternative for the 216-B-50, 216-B-62, 216-C-6, 216-S-9, and 216-S-21 Cribs, and the 216-B-11A and 216-B-11B French Drains is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and workers.

The preferred alternative for UPR-200-W-108 and UPR-200-W-109 is Alternative 3, Removal, Treatment, and Disposal, because this alternative is most protective of human health and the environment, is implementable, and reduces long-term maintenance requirements.

8.1.7 Representative Site 216-B-58 Trench and Its Analogous Waste Sites

The 216-B-58 Trench is the representative site for the 216-B-53A, 216-B-53B, and 216-B-54 Trenches, all of which are located in the BC Cribs and Trenches area. A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-7. The preferred alternative for the 216-B-58, 216-B-53A, 216-B-53B, and 216-B-54 Trenches is Alternative 3, Removal, Treatment, and Disposal, because this alternative is most protective of human health, the environment, the groundwater, and workers.

8.2 PATH FORWARD

A proposed plan has been prepared to document the preferred alternatives for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites (DOE/RL-2004-10, *Proposed Plan for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product-Rich Waste Group Operable Units*). The proposed plan details the closure options, and it documents that the waste sites will be remediated in accordance with the ROD to be developed following issuance of the plan.

The representative sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs were evaluated in this FS, based on data generated through a limited field investigation. The analogous sites for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites were evaluated based on data generated for the representative sites or on site-specific data. The 200 Areas Implementation Plan (DOE/RL-98-28) defines this strategy as a means to streamline RIs and focus the CERCLA process to obtain a decision. As identified in the Implementation Plan, additional sampling phases conducted post-ROD are meant to augment the RI data, confirm the alternative selection, support the design, and provide information for final site closeout. Confirmatory sampling is conducted to confirm that the representative site contaminant distribution model used to evaluate the analogous site is appropriate to the site conditions and to confirm that the appropriate remedial alternative was selected. Design sampling is conducted to obtain data necessary to design the remedial alternative and refine cost estimates from the FS. Verification sampling is conducted to verify that the remediation goals have been met by the implementation of the remedial alternative. Table 8-8 presents the confirmatory, design, and verification sampling phases and presents assumed data needs for each sampling phase for the representative sites and for analogous sites that are similar (or equal) to the representative sites, are less contaminated (or have lower risk) than the representative sites, or are more contaminated (or have higher risk) than the representative sites (see Chapter 2.0 for additional details). This table builds off the decision logic presented in Figure 2-1 and Tables 2-2 through 2-4 (analogous site tables) and provides a basis for initiating the data quality objectives process for the confirmatory sampling and design sampling phases.

Post-ROD sampling needs will be determined through DQO process; a SAP will be developed to direct the sampling needed at the analogous sites. This sampling will be used to confirm that the correct alternative has been selected and to provide design data through a plug-in approach as defined in the following subsections.

Some of the analogous sites likely will undergo a removal, treatment, and disposal alternative; these sites likely will use the observational approach during removal. Sites slated for caps will need additional data to confirm the lateral extent of contaminants and to support remedial design. Sites slated for no action (none currently identified in these OUs) may need verification sampling, depending on the amount, type, and quality of data available to support the no-action decision. The (CERCLA) operation and maintenance sampling could include the monitoring of natural attenuation and performance monitoring of the cap.

8.2.1 Plug-in of the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Unit Waste Sites

The plug-in approach is a process that helps make remedial action decisions for additional waste sites using existing CERCLA evaluations. In the future, the plug-in approach is proposed for any similar waste sites already defined within the 200-TW-1, 200-TW-2, and 200-PW-5 OUs and for newly discovered waste sites that have a conceptual site model that is similar to those of waste sites already addressed in this FS. The plug-in approach will be used on the analogous sites considered in this FS after additional data are collected in the confirmatory and design sampling phases.

The plug-in approach benefits the goal of remediating waste sites within the OUs in conjunction with the analogous site approach. The traditional CERCLA approach for remedy selection would require the development of multiple proposed plans and RODs that, for similar sites, would be nearly identical to the feasibility studies, proposed plans, and RODs already developed and proven to be successful. The plug-in approach allows remedial actions to begin much more quickly at a waste site, without the need for redundant remedy selection processes.

The plug-in approach requires three main elements to establish its use as a cost-effective tool for remediation.

- First, multiple sites must be identified that share common physical and contaminant characteristics. These characteristics are referred to as the conceptual site model.
- Second, a remedial alternative, or standard remedy, must be established that has been shown to be protective and cost-effective for sites that share the common conceptual site model.
- Lastly, sites sharing a common conceptual site model must be shown to require remedial action because of contaminant concentrations that pose risk to human health and the environment.

To use the plug-in approach for a waste site not evaluated in this FS, the site must fit the defined conceptual model and must be shown to require remedial action. The site then can be "plugged in" to the standard remedy. The following information describes how the plug-in approach is proposed to be used for remedy selection.

8.2.1.1 Establishing the Conceptual Site Model

Four conceptual site models have been defined based on the site characteristics contained in the Feasibility Study. These characteristics include the following:

- Type of contaminant inventory
- Concentrations of contaminants in environmental media
- Types of contaminated environmental media (soil) or material (e.g., concrete, metal, wood)
- Extent of contamination within the environment (that is, the depth of discharge, the expected contaminant distributions, and the potential for hydrologic and contaminant impacts to groundwater).

Based on the representative sites evaluated in this FS, the following five conceptual site models were developed:

- Waste sites where no hazardous material was disposed of at the waste site or where contaminants disposed of currently meet the RAOs
- Waste sites where limited contamination exists at the waste sites, an existing soil cover is in place and of sufficient thickness to provide protection, contaminants are expected to meet the RAOs during the institutional control period (such as within 150 years), and groundwater PRGs are not exceeded. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes
- Waste sites where contaminants exceed the RAOs and contamination is shallow, low-volume, and can be cost effectively remedied through removal, treatment, and disposal. Typically, these contaminants exceed the human health and ecological PRGs; however, groundwater PRGs are not exceeded at depths that make excavation impracticable. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes
- Waste sites where contaminants exceed the PRGs, where contaminants are at concentrations that pose a significant worker risk, and where the contaminants having the potential to adversely impact groundwater are at significant depth. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes
- Waste sites where contaminants exceed the PRGs, where contaminants are at concentrations that would not pose a significant worker risk, and where the contaminants having the potential to adversely impact groundwater are at significant depth. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.

8.2.1.2 Establishment of the Standard Remedy

The standard remedies, based on the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites, have been defined on the basis of the conceptual models presented by the representative waste sites, as well as the alternative evaluations conducted for all waste sites. As such, five standard remedies are identified for potential plug-in sites. These remedies are provided below along with their required characteristics.

- **Alternative 1: No Action** has been defined as a standard remedy for waste sites whose conceptual site model indicates that no hazardous materials were disposed at the waste site or that contaminants disposed of currently meet the RAOs.

- **Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation** has been defined as the standard remedy for waste sites whose conceptual site model indicates that limited contamination exists at the waste sites, an existing soil cover is in place and of sufficient thickness to provide protection, contaminants are expected to meet the RAOs during the institutional control period (such as within 150 years), and groundwater PRGs are not exceeded. Contaminated environmental media are similar to the media exhibited by the waste sites included in this FS. These media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.

- **Alternative 3: Removal, Treatment, and Disposal** has been defined as the standard remedy for waste sites whose conceptual site model indicates that contaminants exceed the RAOs and that contamination is shallow, low-volume, and can be cost effectively remedied through the removal, treatment, and disposal of contaminated media. Typically, as shown in the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites, these contaminants exceed the human health and ecological PRGs; however, groundwater PRGs are not exceeded at depths that make excavation impracticable. Contaminated environmental media are similar to the media exhibited by the waste sites included herein. These media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.

- **Alternative 4: Capping** has been defined as the standard remedy for waste sites whose conceptual site model indicates that contaminants exceed the RAOs and that the contaminants at greater depths have a potential to adversely impact groundwater. Contaminant concentrations and contaminated environmental media are similar to the media exhibited by the waste sites included in this FS. These media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes. Contaminant concentrations would indicate the potential to adversely impact groundwater and would pose significant worker protection and intruder risk. Contaminants may also pose a risk to humans and ecological receptors, depending on the depth to the top of the contamination.

- **Alternative 5: Partial Removal, Treatment, and Disposal with Capping** has been defined as the standard remedy for waste sites where contaminants exceed the PRGs, where contaminants in the near-surface are at concentrations that would not pose a significant worker risk but would result in substantial risk reduction, and where the contaminants having the potential to adversely impact groundwater are at significant depth. The contaminants that can be excavated readily would be removed, and the remaining contaminants would be capped to provide groundwater protection. Contaminant concentrations and media generally are less than the contaminant concentrations and media exhibited by the waste sites included in this FS; however, the concentrations are high enough to result in real risk reduction in the near-surface without exposing workers to unacceptable risks. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes. Cost analysis would be required to ensure that this alternative is cost-effective when compared to either Alternative 3 or Alternative 4.

8.2.1.3 Establishing the Need for Remedial Action

Waste sites that share a common conceptual site model will "plug in" to the standard remedy if they are determined to require remedial action because of a risk to human health and the environment (based on the RAOs and associated PRGs, as defined previously). Some of the waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs likely will require confirmatory sampling to validate the conceptual site model and the identified preferred remedy. The preferred remedy will be implemented following confirmation of the conceptual site model. Should the confirmatory sampling indicate variations in the defined conceptual site model, this plug-in approach will be used to define the appropriate remedy.

8.3 PUBLIC INVOLVEMENT IN THE PLUG-IN APPROACH

To ensure that the public is involved in the application of the plug-in approach, the Tri-Parties will publish explanations of significant differences at the following points in the plug-in process:

- When newly discovered waste sites are proven through analysis to be above remediation goals and able to plug in to the standard remedy
- When confirmatory sampling identified for the waste sites discussed herein indicates variations in the defined conceptual site model such that the preferred remedy is no longer protective.

Table 8-1. Preferred Alternatives for the Representative Site 216-B-46 Crib and Its Analogous Waste Sites (2 Pages).

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-46 Crib with Analogous Sites 216-B-43 through 216-B-45 Cribs and 216-B-47 through 216-B-49 Cribs (also known as the BY Cribs)				**☑**	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$15	$399,703	$3,226	$19,618
Operating and maintenance costs	$0	$1,713	$0	$2,322	$2,175
Present worth	$0	$1,728	$399,703	$5,548	$21,793
Analogous Sites 216-B-14 through 216-B-19 Cribs, 216-B-20 through 216-B-34 Trenches, 216-B-42 Trench, 216-B-52 Trench, 216-BY-201 Settling Tank, 200-E-14 Siphon Tanks, and UPR-200-E-9				**☑**	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$12,264	$3,249,276	$48,728	$298,840
Operating and maintenance costs	$0	$26,895	$0	$51,006	$33,126
Present worth	$0	$39,159	$3,249,276	$99,734	$331,966
Analogous Sites 216-B-51 French Drain and 200-E-114 Pipeline[d]		**☑**			
Threshold Criteria					
Overall Protection	☐	☑	☑	☑	NA
Compliance with Laws	☐	☑	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◈	◆	◆	NA
Short-term effectiveness	◈	◆	◇	◈	NA
Reduction in TMV[c]	◈	◈	◈	◈	NA
Implementability	◆	◆	◈	◆	NA
Cost (in thousands)					
Capital costs	$0	$15	$209,967	$3,195	NA
Operating and maintenance costs	$0	$2,101	$0	$3,946	NA
Present worth	$0	$2,116	$209,967	$6,141	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment
d. The portion of the 200-E-114 Pipeline from the BC Cribs (216-B-14 through 216-B-19) to Route 4 South will be removed to support BC Cribs and Trenches remedial actions and as confirmatory sampling to support the remedy proposed for the rest of the pipeline.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: substantially satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: minimally satisfies criterion

Table 8-2. Preferred Alternative for the Representative Site 216-T-26 Crib and Its Analogous Waste Site.

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-T-26 Crib				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$15	$39,576	$639	$1,395
Operating and maintenance costs	$0	$671	$0	$487	$675
Present worth	$0	$686	$39,576	$1,126	$2,070
Analogous Site 216-T-18				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$15	$39.576	$689	$1,395
Operating and maintenance costs	$0	$671	$0	$487	$675
Present worth	$0	$686	$39,576	$1,126	$2,070

a. Maintain existing soil cover, institutional controls, monitored naturalattenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: best satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: least satisfies criterion

Table 8-3. Preferred Alternative for the Representative Site 216-B-5 Injection/Reverse Well and Its Analogous Waste Site.

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-5 Injection/Reverse Well		☑			
Threshold Criteria					
Overall Protection	☐	☑	☑	☑	NA
Compliance with Laws	☐	☑[c]	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◈	◆	◇	NA
Short-term effectiveness	◈	◆	◇	◈	NA
Reduction in TMV[d]	◈	◈	◈	◈	NA
Implementability	◆	◆	◇	◈	NA
Cost (in thousands)[e]					
Capital costs	$0	$237	$102,830	$1,048	$0
Operating and maintenance costs	$0	$677	$0	$579	$0
Present worth	$0	$914	$102,830	$1,627	$0
Analogous Site 216-T-3 Inejection/Reverse Well		☑			
Threshold Criteria					
Overall Protection	☐	☑	☑	☑	NA
Compliance with Laws	☐	☑[c]	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◈	◆	◇	NA
Short-term effectiveness	◈	◆	◇	◈	NA
Reduction in TMV[d]	◈	◈	◈	◈	NA
Implementability	◆	◆	◇	◈	NA
Cost (in thousands)[e]					
Capital costs	$0	$237	$49,552	$1,048	$0
Operating and maintenance costs	$0	$677	$0	$579	$0
Present worth	$0	$914	$49,552	$1,627	$0

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. ARAR waiver required
d. Toxicity, mobility, or volume through treatment
e. Includes decommissioning of reverse well except for no action.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: substantially satisfies criterion
◈ Moderate: partially satisfies criterion
◇ Low: minimally satisfies criterion

Table 8-4. Preferred Alternative for the Representative Site 216-B-7A Crib and Its Analogous Waste Sites (2 Pages).

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-7A Crib				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$15	$244,003	$1,412	$1,386
Operating and maintenance costs	$0	$668	$0	$756	$282
Present worth	$0	$683	$244,003	$2,168	$1,917
Analogous Sites 216-B-7B, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32 Cribs; 216-T-5 Trench; and 200-E-45 Sampling Shaft				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$219	$1,684,815	$13,317	$59,279
Operating and maintenance costs	$0	$11,349	$0	$13,601	$5,998
Present worth	$0	$11,568	$1,684,815	$26,918	$65,277
Analogous Site UPR-200-E-7			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	NA
Short-term effectiveness	◈	◈	◈	◈	NA
Reduction in TMV[c]	◈	◈	◈	◈	NA
Implementability	◆	◆	◆	◆	NA
Cost (in thousands)					
Capital costs	$0	$0[e]	$265	$14	NA
Operating and maintenance costs	$0	$412	$0	$650	NA
Present worth	$0	$412	$265	$664	NA
Analogous Sites 241-B-361 and 241-T-361 Settling Tanks[d]		☑			
Threshold Criteria					
Overall Protection	☐	☑	☑	☑	NA
Compliance with Laws	☐	☑	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◈	◆	◆	◆	NA

Table 8-4. Preferred Alternative for the Representative Site 216-B-7A Crib and Its Analogous Waste Sites (2 Pages).

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Short-term effectiveness	◆	◈	◈	◈	NA
Reduction in TMV[c]	◈	◈	◈	◈	NA
Implementability	◆	◆	◇	◆	NA
Cost (in thousands)					
Capital costs	$0	$12,031	$14,156	$14,617	NA
Operating and maintenance costs	$0	$1,000	$0	$1,369	NA
Present worth	$0	$13,362	$14,156	$15,986	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Remove, treat, dispose
c. Toxicity, mobility, or volume through treatment
d. Includes removal of sludge except under no action
e. Capital cost less than $1,000

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: best satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: least satisfies criterion

Table 8-5. Preferred Alternative for the Representative Site 216-B-38 Trench and Its Analogous Waste Sites.

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-38 Trench with 216-B-35 through 216-B-37 Trenches and 216-B-39 through 216-B-41 Trenches				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$15	$1,036,242	$6,394	$70,487
Operating and maintenance costs	$0	$3,703	$0	$4,742	$4,562
Present worth	$0	$3,718	$1,036,242	$11,136	$75,049
Analogous Sites 216-T-14 through 216-T-17 Trenches and 216-T-21 through 216-T-25 Trenches				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[c]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$16	$1,458,056	$6,490	$72,742
Operating and maintenance costs	$0	$3,758	$0	$4,812	$4,708
Present worth	$0	$3,774	$1,458,056	$11,302	$77,450

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: best satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: least satisfies criterion

Table 8-6. Preferred Alternative for the Representative Site 216-B-57 Crib and Its Analogous Waste Sites.

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-57 Crib[c]		**☑**			
Threshold Criteria					
Overall Protection	☐	☑	☑	☑	NA
Compliance with Laws	☐	☑	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◈	◆	◆	◆	NA
Short-term effectiveness	◆	◆	◈	◈	NA
Reduction in TMV[d]	◈	◈	◈	◈	NA
Implementability	◆	◆	◇	◆	NA
Cost (in thousands)					
Capital costs	$0	$15	$0	$0	NA
Operating and maintenance costs	$0	$687	$0	$0	NA
Present worth	$0	$702	NA[e]	NA[e]	NA[e]
Analogous Sites 216-B-50 Crib, 216-B-11A&B French Drains, 216-B-62 Crib, 216-C-6 Crib, 216-S-9 Crib, and 216-S-21 Crib				**☑**	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	◆
Short-term effectiveness	◈	◈	◇	◆	◇
Reduction in TMV[d]	◈	◈	◈	◈	◈
Implementability	◆	◆	◇	◆	◇
Cost (in thousands)					
Capital costs	$0	$60	$131,844	$4,189	$33,280
Operating and maintenance costs	$0	$4,142	$0	$5,248	$4,128
Present worth	$0	$4,202	$131,844	$9,437	$37,408
Analogous Site Unplanned Release UPR-200-W-108 and UPR-200-W-109			**☑**		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◈	NA
Short-term effectiveness	◈	◈	◈	◈	NA
Reduction in TMV[d]	◈	◈	◈	◈	NA
Implementability	◇	◇	◆	◈	NA
Cost (in thousands)					
Capital costs	$0	$15	$169	$373	NA
Operating and maintenance costs	$0	$349	$0	$335	NA
Present worth	$0	$409	$169	$708	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Costs for capping and partial removal/capping at 216-B-57 are included to support evaluation of analogous sites; a Hanford Barrier currently exists at the site.
d. Toxicity, mobility, or volume through treatment.
e. This site has Hanford Barrier therefore, this alternative is NA.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: best satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: least satisfies criterion

Table 8-7. Preferred Alternative for the Representative Site 216-B-58 Trench and Its Analogous Waste Sites.

	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-58 Trench			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	NA
Short-term effectiveness	◈	◈	◈	◆	NA
Reduction in TMV[c]	◈	◈	◈	◈	NA
Implementability	◆	◆	◆	◆	NA
Cost (in thousands)					
Capital costs	$0	$15	$1,531	$958	NA
Operating and maintenance costs	$0	$680	$0	$745	NA
Present worth	$0	$695	$1,531	$1,703	NA
Analogous Sites 216-B-53A Trench[d], 216-B-53B Trench, and 216-B-54 Trench			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◆	NA
Short-term effectiveness	◈	◈	◈	◆	NA
Reduction in TMV[c]	◈	◈	◈	◈	NA
Implementability	◆	◆	◆	◆	NA
Cost (in thousands)					
Capital costs	$0	$46	$4,820	$2,862	NA
Operating and maintenance costs	$0	$2,030	$0	$2,918	NA
Present worth	$0	$2,076	$4,820	$5,780	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment
d. 216-B-53A Trench received 100 g Pu; therefore the Hanford Barrier is assumed in the cost estimate.

☑	Indicates the preferred alternative
☑	Yes, meets criterion
☐	No, does not meet criterion
◆	High: best satisfies criterion
◈	Moderate: partially meets criterion
◇	Low: least satisfies criterion

Table 8-8. Potential Post-Record of Decision Sampling. (2 Pages)

Alternative	Confirmatory Sampling						Design Sampling	Verification Sampling		
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify PRG Attainment
Alternative 1 - No Action								X	X	X
Alternative 2 - Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation										
Representative site			X		X				X	
Analogous site equal to representative site			X							
Analogous site less than representative site	X	X	X	If an issue at Rep Site						
Analogous site greater than representative site	X	X	X	If not an issue at Rep Site	X				X	
Alternative 3 – Removal, Treatment, and Disposal										
Representative site						X			X	X
Analogous site equal to representative site						X				X
Analogous site less than representative site	X					X				X
Analogous site greater than representative site						X			X	X

Table 8-8. Potential Post-Record of Decision Sampling. (2 Pages)

Alternative	Confirmatory Sampling						Design Sampling	Verification Sampling		
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify PRG Attainment
Alternative 4 – Capping										
Representative site					X		X		X	
Analogous site equal to representative site							X			
Analogous site less than representative site	X						X			
Analogous site greater than representative site					X		X		X	
Alternative 5 – Partial Removal, Treatment, and Disposal with Capping										
Representative site						X	X		X	X
Analogous site equal to representative site						X	X			X
Analogous site less than representative site	X			X		X	X			X
Analogous site greater than representative site				X		X	X		X	X

PRG = preliminary remediation goal.

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WAC-173-340-900, "Tables," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

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WHC-SD-EN-TI-014, 1992, *Hydrogeologic Model of the 200 West Groundwater Aggregate Area*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-ER-133, 1991, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*, Westinghouse Hanford Company, Richland, Washington.

WNHP, 1998, *Washington Rare Plant Species by County*, Washington Natural Heritage Program, available at http://www.wa.gov/dnr/htdocs/fr/nhp/plantco.html#benton

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APPENDIX A

WASTE SITE PHOTOGRAPHS

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FIGURES

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APPENDIX A

WASTE SITE PHOTOGRAPHS

Figure A-1. 200-E-45 Shaft.

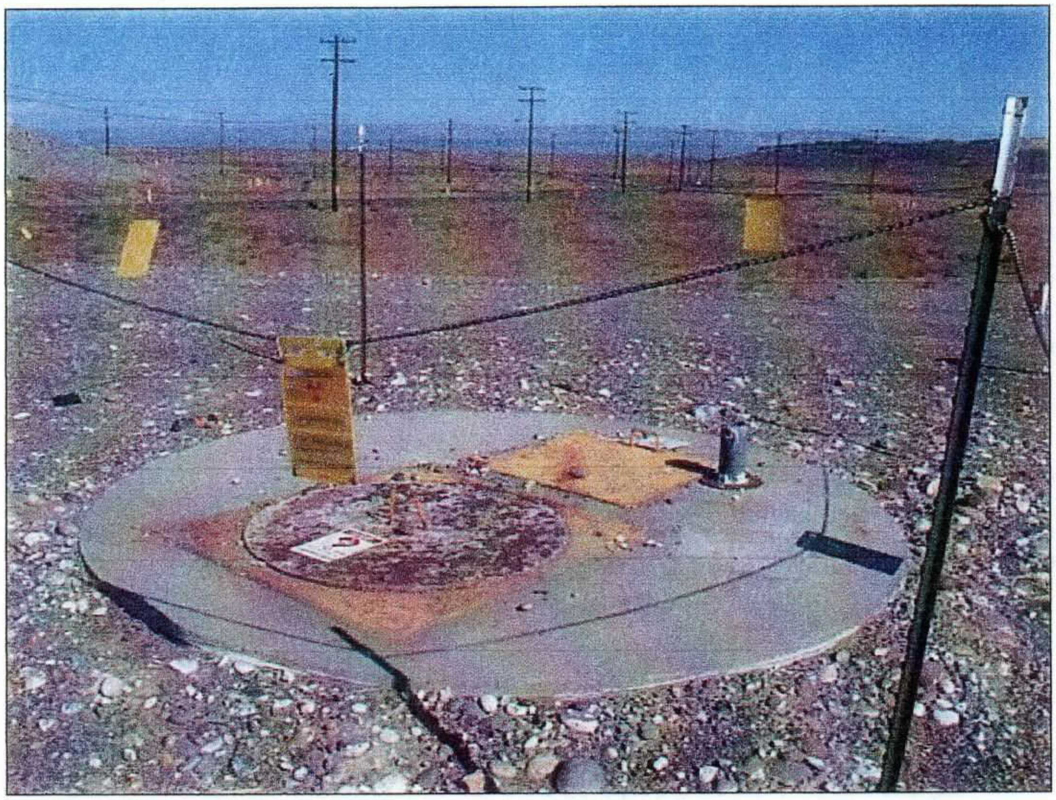

Figure A-2. 216-B-7A Crib.

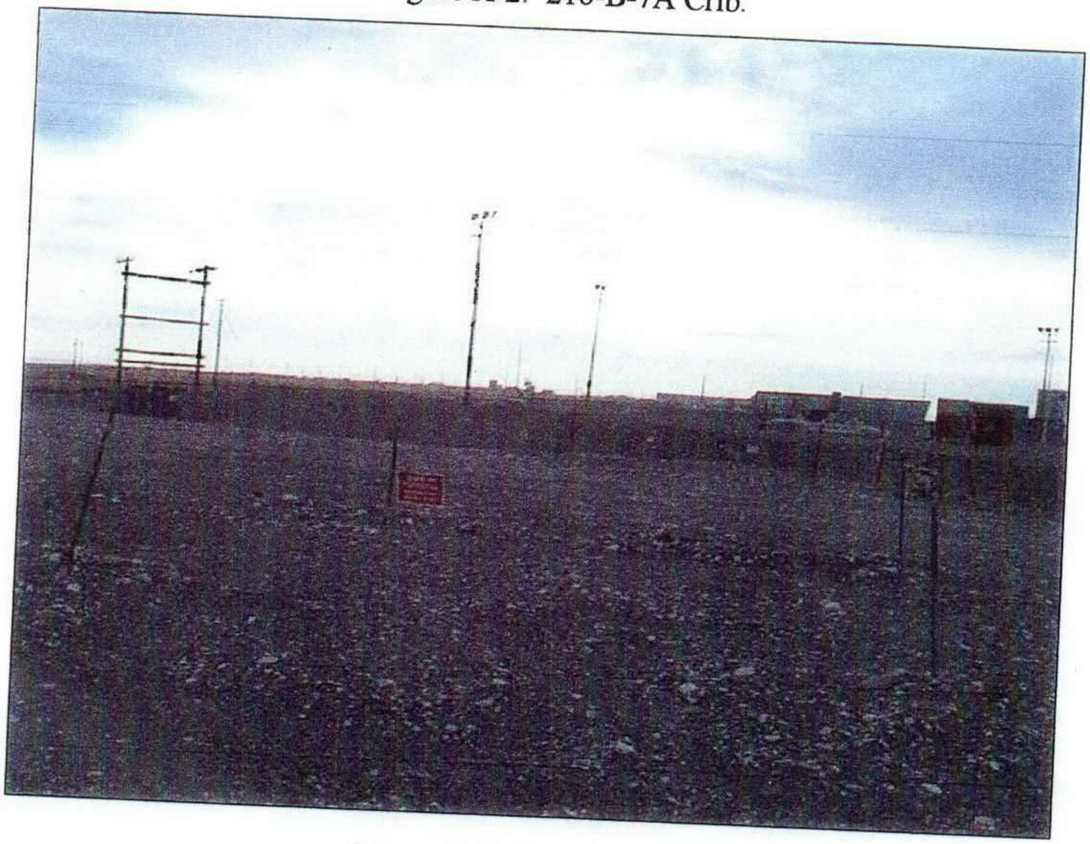

Figure A-3. 216-B-8 Crib.

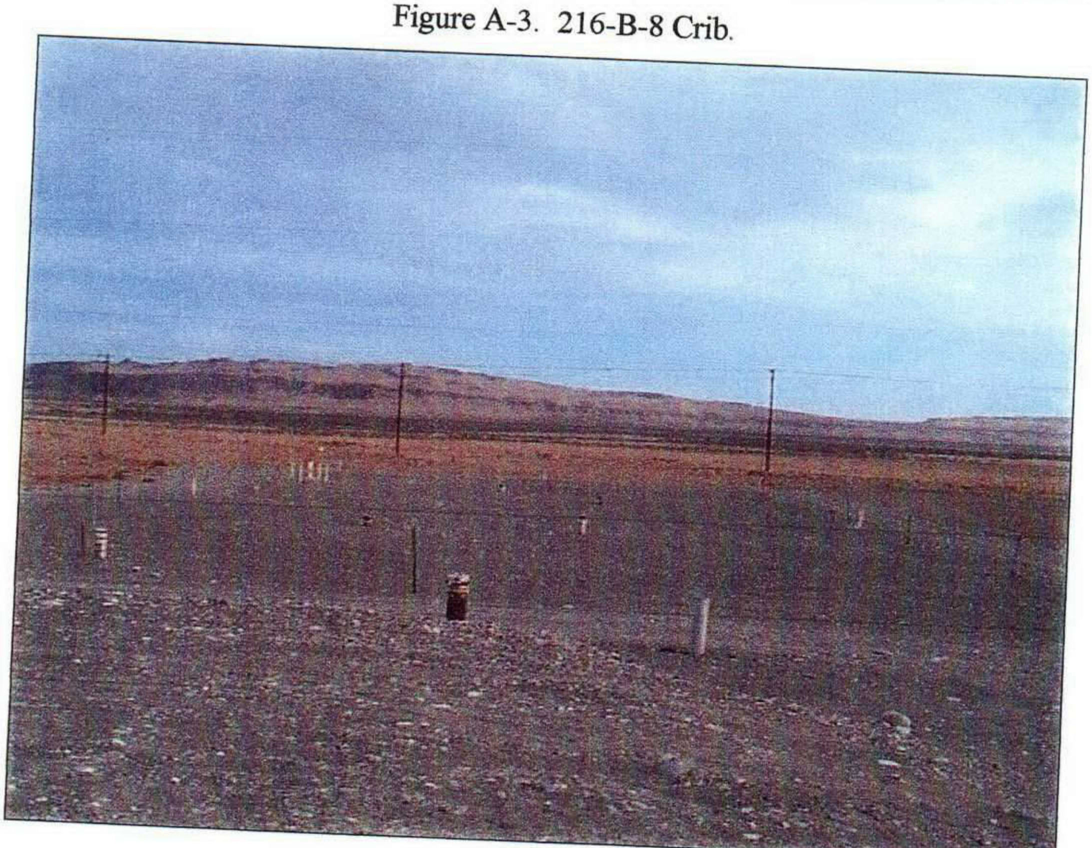

Figure A-4. 216-B-9 Crib.

Figure A-5. 216-T-3 Injection/Reverse Well.

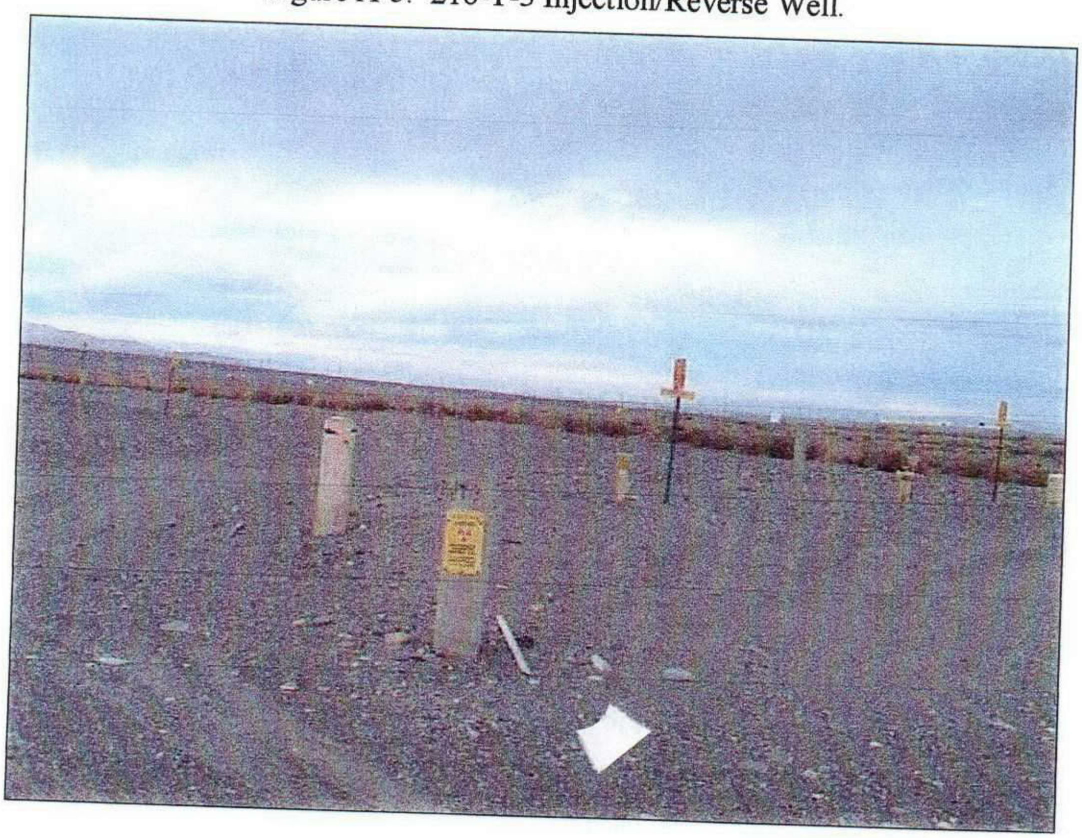

Figure A-6. 216-T-5 Trench and 216-T-7 Crib.

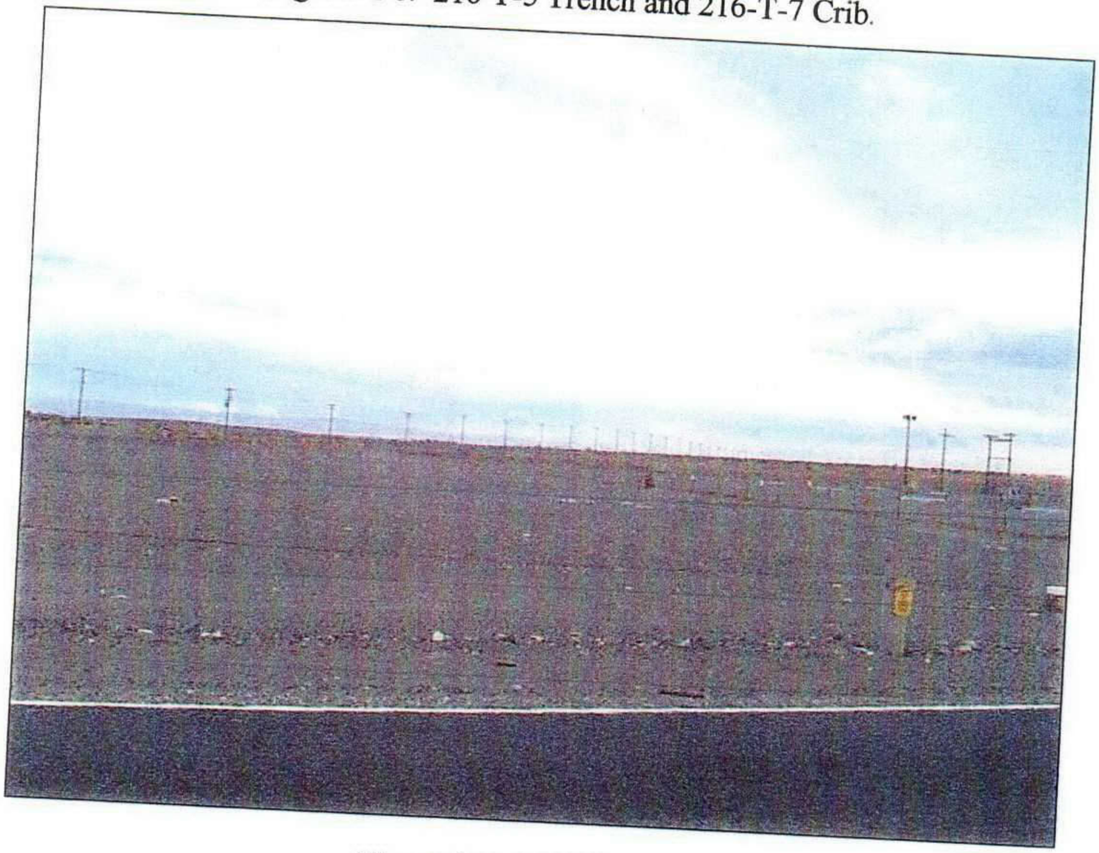

Figure A-7. 216-T-6 Crib.

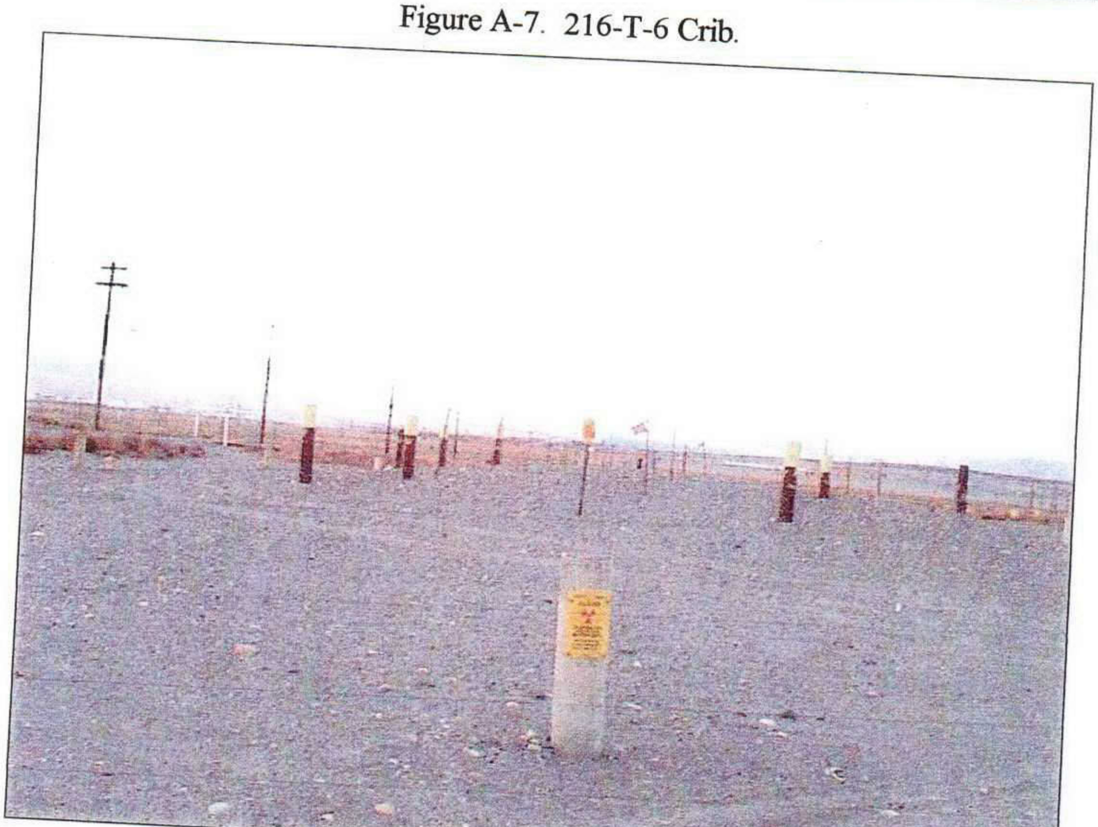

Figure A-8. 216-T-14 through 216-T-17 Trenches.

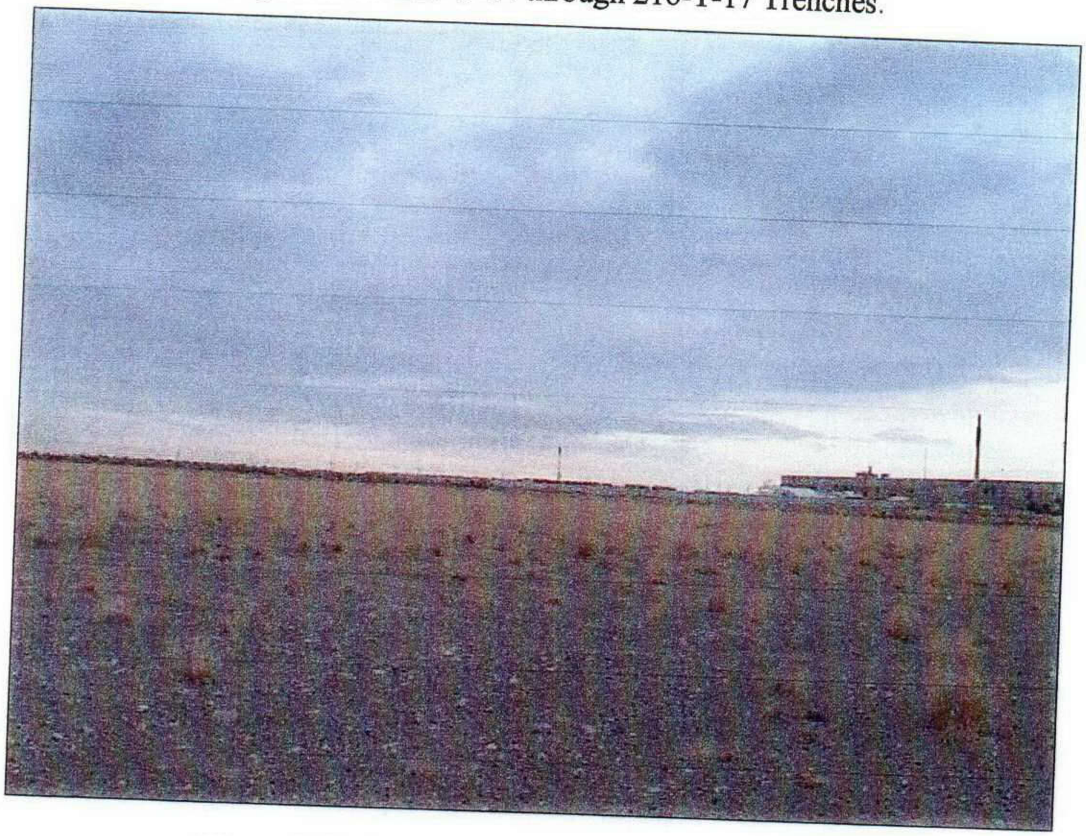

Figure A-9. 216-T-21 through 216-T-25 Trenches.

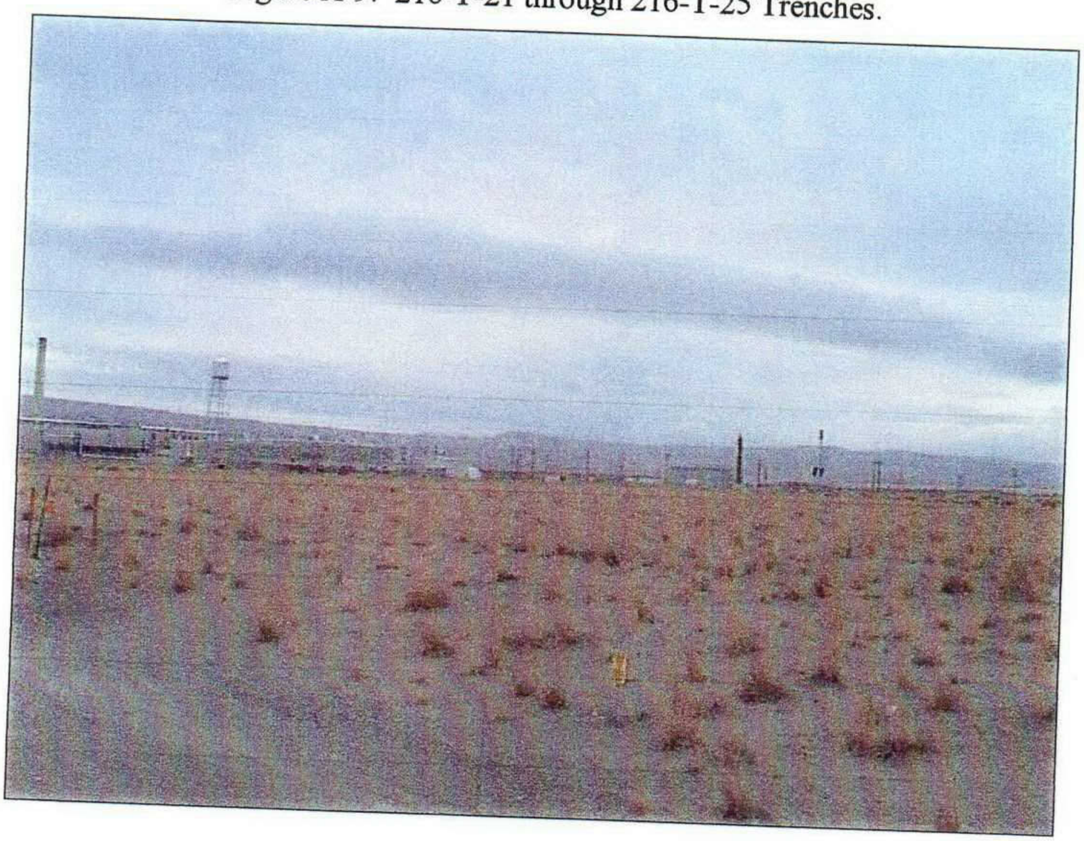

Figure A-10. 216-T-32 Crib.

Figure A-11. 241-B-361 Settling Tank.

Figure A-12. 216-B-35 through 216-B-42 Trenches.

Figure A-13. 241-T-361 Settling Tank.

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APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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CONTENTS

TABLES

TERMS

AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
MCL	maximum contaminant level
NRC	U.S. Nuclear Regulatory Commission
OU	Operable Unit
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
TBC	to be considered
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*

APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B1.0 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARAR) for waste site remediation for the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units (OU). The potential ARARs identified in this document have been used to form the basis for the levels to which contaminants must be remediated to protect human health and the environment. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides for the identification of to-be-considered (TBC) nonpromulgated advisories, criteria, guidance, or proposed standards that may be consulted to interpret ARAR to-be-determined remediation goals when ARARs do not exist or are insufficient. Independent of the TBC and ARARs identification process at the Hanford Site, the requirements of U.S. Department of Energy (DOE) orders must be met.

Because the waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs will be remediated under a CERCLA decision document, remedial and corrective actions at the sites will be required to meet ARARs. This appendix identifies and evaluates potential ARARs for these sites. Final ARARs for remediation will be established in the record of decision (ROD). In many cases, the ARARs form the basis for the preliminary remediation goals to which contaminants must be remediated to protect human health and the environment. In other cases, the ARARs define or restrict how specific remedial measures can be implemented.

The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*, and EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*). Section 121 of CERCLA, as amended, requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation promulgated under any Federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain onsite after completion of remedial action.

Under this process, potential ARARs are classified into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows.

- Chemical-specific requirements usually are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety levels and site cleanup levels.

- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.

- Action-specific requirements usually are technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

When requirements in each category are identified, a determination must be made as to whether those requirements are ARARs. A requirement applies if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. Even if not applicable, a requirement may be relevant and appropriate if, based on best professional judgment, circumstances at the site are sufficiently similar to the problems or situations regulated by the requirement and the requirement's use is well suited to the site. Only the substantive requirements (e.g., use of control or containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA onsite activities. ARARs associated with administrative requirements, such as permitting, do not apply to CERCLA onsite activities (CERCLA, Section 121[e][1]). In general, this CERCLA permitting exemption will be extended to all remedial- and corrective-action activities conducted at the 200-TW-1, 200-TW-2, and 200-PW-5 OUs. The exception to this general application of the CERCLA permitting exemption is the *Resource Conservation and Recovery Act of 1976* (RCRA) units, which will be incorporated into WA7890008967, *Hanford Facility RCRA Permit*.

TBC information is nonpromulgated advisories or guidance issued by Federal and state governments that is not legally binding and does not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action needed to protect human health and the environment. The TBCs complement the ARARs in determining protectiveness at a site or implementing certain actions. For example, because soil cleanup standards do not exist for all contaminants, health advisories, which would be TBCs may be helpful in defining appropriate remedial action goals.

B1.1 WAIVERS FROM APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The U.S. Environmental Protection Agency (EPA) may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. Section 121 of the *Superfund Amendments and Reauthorization Act of 1986* identifies the following six circumstances in which the EPA may waive ARARs for onsite remedial actions.

- The remedial action selected is only a part of a total remedial action (such as an interim action) and the final remedy will attain the ARAR upon its completion

- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options

- Compliance with the ARAR is technically impracticable from an engineering perspective

- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach

- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

B1.2 POTENTIAL ARARS APPLICABLE TO REMEDIAL ACTIONS FOR WASTE SITES IN THE 200-TW-1, 200-TW-2 AND 200-PW-5 OPERABLE UNITS

Potential Federal and state ARARs are presented in Tables B-1 and B-2, respectively. The chemical-specific ARARs and TBCs likely to be most relevant to remediation of the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites are elements of the Washington State regulations that implement *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup," specifically associated with developing risk-based concentrations for cleanup (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties") and the EPA's memorandum EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, OSWER Directive 9200.4-31P. The requirements of WAC 173-340-745 risk-based concentrations and the EPA memorandum help establish soil cleanup standards for nonradioactive and radioactive contaminants at waste sites. The several Federal and state air emission standards are likely to be important in identifying air emission limits and control requirements for any remedial actions that produce air emissions. RCRA land-disposal restrictions will be important standards during the management of waste generated during remedial actions.

No location-specific ARARs have been identified for the waste sites considered in this focused feasibility study.

Action-specific ARARs that could be pertinent to remediation are state solid and dangerous waste regulations (for management of characterization and remediation waste and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions.

B2.0 REFERENCES

10 CFR 20, "Standards for Protection Against Radiation," Title 10, *Code of Federal Regulations*, Part 20, as amended.

10 CFR 61, "Licensing Requirements for the Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61, as amended.

10 CFR 71, "Packaging and Transportation of Radioactive Material," Title 10, *Code of Federal Regulations*, Part 71, as amended.

10 CFR 835, "Occupational Radiation Protection," Title 10, *Code of Federal Regulations*, Part 835, as amended.

40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards," Title 40, *Code of Federal Regulations*, Part 50, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, Subpart I, "National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H," Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 124, "Procedures for Decisionmaking," Title 40, *Code of Federal Regulations*, Part 124, as amended.

40 CFR 141, "National Primary Drinking Water Standards," Title 40, *Code of Federal Regulations*, Part 141, as amended.

40 CFR 260 through 268, (Chapter I – Environmental Protection Agency, Subchapter 1, Solid Wastes), *Code of Federal Regulations*, as amended.

40 CFR 300, National Oil and Hazardous Substances Pollution Contingency Plan (Chapter I – Environmental Protection Agency, Subchapter J – Superfund, Emergency Planning, and Community Right-To-Know Programs), *Code of Federal Regulations*, as amended.

40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," *Code of Federal Regulations*, Title 40, *Code of Federal Regulations*, Part 761, as amended.

Atomic Energy Act of 1954, 42 USC 2011, et seq.

BHI-00139, 1998, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, Rev. 3, Bechtel Hanford, Inc, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

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EPA/540/G-89/006, 1988, *CERCLA Compliance with Other Laws Manual: Interim Final*, U.S. Environmental Protection Agency, Washington, D.C.

EPA/540/R-99/006, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive No. 9200.4-31P, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Superfund Amendments and Reauthorization Act of 1986, 42 USC 103, et seq.

WA7890008967, 1994, *Hanford Facility RCRA Permit*, Washington State Department of Ecology, Olympia, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-350, "Solid Waste Handling Standards," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-470, "Ambient Air Quality Standards for Particulate Matter," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 246-247, "Radiation Protection – Air Emissions," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"National Primary Drinking Water Standards," 40 CFR 141			
"Maximum Contaminant Levels for Organic Contaminants," 40 CFR 141.61	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of organic contaminants in drinking water.	The groundwater associated with the TW-1, TW-2, and PW-5 OUs currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the requirements in 40 CFR 141.61 for organic constituents are relevant and appropriate.
"Maximum Contaminant Levels for Inorganic Contaminants," 40 CFR 141.62	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of inorganic contaminants in drinking water.	The groundwater associated with the TW-1, TW-2, and PW-5 OUs currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the requirements in 40 CFR 141.62 for inorganic constituents are relevant and appropriate.
"Maximum Contaminant Levels for Radionuclides," 40 CFR 141.66	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of radionuclides in drinking water.	The groundwater associated with the TW-1, TW-2, and PW-5 OUs currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the requirements in 40 CFR 141.66 for radionuclides are relevant and appropriate.
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Disposal Requirements," 40 CFR 761.60	ARAR	Identifies standards applicable to the handling and disposal of PCB liquids and articles.	This requirement is relevant and appropriate because PCB waste may be encountered during the remediation of the TW-1, TW-2, and PW-5 OUs.
"PCB Remediation Waste," 40 CFR 761.61	ARAR	Establishes the cleanup and disposal options for PCB remediation waste.	This requirement is relevant and appropriate because PCB remediation waste may be encountered during the remediation of the TW-1, TW-2, and PW-5 OUs.
"National Primary and Secondary Ambient Air Quality Standards," 40 CFR 50			
"National primary and secondary ambient air quality standards for particulate matter," 40 CFR 50.7	ARAR	Establishes the primary and secondary air quality standards for particulate matter, which are 15 $\mu g/m^3$ annually or 65 $\mu g/m^3$ per 24-hour average concentration.	This regulation is applicable to airborne releases of radionuclides and criteria pollutants that may be generated during characterization or remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"National Emission Standards for Hazardous Air Pollutants," 40 CFR 61			
"Lists of Pollutants and applicability of Part 61," 40 CFR 61.01	ARAR	Establishes the list of hazardous air pollutants.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Prohibited Activities," 40 CFR 61.05	ARAR	Prohibits the owner/operator from constructing or modifying stationary sources without approval by the regulatory agencies. This regulation also prohibits operating a stationary source that is in violation of any national emission standard unless specifically exempted. The owner/operator also may not operate any existing source that is subject to national emission standards, in violation of the standards.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Compliance with Standards and Maintenance Requirements," 40 CFR 61.12	ARAR	Requires the owner/operator of each stationary source to maintain and operate the source and associated air pollution control equipment in a manner that minimizes emissions.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Monitoring Requirements," 40 CFR 61.14	ARAR	Requires the owner/operator to maintain and operate each monitoring system in a manner consistent with air pollution control practices for minimizing emissions. The regulation also establishes the requirements for installing monitoring systems.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Standard," 40 CFR 61.92	ARAR	Requires that emissions of radionuclides to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Emission Monitoring and Test Procedures," 40 CFR 61.93	ARAR	Establishes the methods for monitoring emissions rates from existing point sources.	This requirement applies to remedial actions that release air emissions into unrestricted areas. Therefore, this regulation is applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"National Emission Standard for Asbestos," 40 CFR 61 Subpart M; "Applicability," 40 CFR 61.140			
"Standard for Demolition and Renovation," 40 CFR 61.145	ARAR	Specifies that facilities are to be inspected for the presence of asbestos before demolition. The standard defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. These requirements also specify handling and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of asbestos-containing materials.	Although asbestos-containing materials are not anticipated, these requirements are applicable if asbestos is found during remediation of associated pipelines and buried asbestos.
"Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations," 40 CFR 61.150	ARAR	Identifies the requirements for the removal and disposal of asbestos during demolition and renovation activities.	Although asbestos-containing materials are not anticipated, these requirements would be applicable if asbestos is found during the remediation of pipelines or other waste sites.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Standards for Protection Against Radiation," 10 CFR 20			
"Occupational Dose Limits for Adults," 10 CFR 20.1201	ARAR	Specifies the annual occupational dose limits to adults. The standard sets the annual dose equivalent for individual adults and shall not exceed 5 rem/yr for whole body; 50 rem/yr for deep-dose equivalent and committed dose equivalent to any individual organ or tissue (excluding the lens of the eye); 15 rem/yr for the lens of the eye; and 50 rem/yr for skin or any other extremity. The standard also establishes the limit of soluble uranium intake by an individual adult to 10 mg/wk.	The regulation establishes standards for protecting the public against radiation arising from the use of regulated materials and, therefore, is relevant and appropriate. Radioactive material from sources not licensed by the NRC are not subject to these regulations; therefore, this standard is not applicable because the Hanford Site operations are not NRC licensed.
"Dose Equivalent to an Embryo/Fetus," 10 CFR 20.1208	ARAR	Specifies the annual dose limits to an embryo/fetus. The standard sets the annual dose equivalent during the entire pregnancy, caused by an occupational exposure of a declared pregnant woman, to be below 0.5 rem/yr.	The regulation establishes standards for protecting an embryo/fetus from radiation arising from the use of regulated materials and, therefore, is relevant and appropriate. Radioactive materials from sources not licensed by the NRC are not subject to these regulations; therefore, this standard is not applicable because the Hanford Site operations are not NRC licensed.
"Dose Limits for Individual Members of the Public," 10 CFR 20.1301	ARAR	Specifies the total effective dose equivalent to individual members of the public from operations to not exceed 0.1 rem/yr.	The regulation establishes standards for protecting the public against radiation arising from the use of regulated materials and, therefore, is relevant and appropriate. Radioactive materials from sources not licensed by the NRC are not subject to these regulations; therefore, this standard is not applicable because the Hanford Site operations are not NRC licensed.
"Occupational Radiation Protection," 10 CFR 835			
"Occupational Dose Limits for General Employees," 10 CFR 835.202	ARAR	Establishes the occupational dose limits for general employees. The total effective dose equivalent is 5 rem/yr (the sum of the deep-dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye); the lens of the eye dose equivalent is set at 15 rem/yr; the shallow dose equivalent of 50 rem/yr to the skin or to any extremity.	Standards for occupational dose limits are applicable to remediation waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Combining Internal and External Dose Equivalents," 10 CFR 835.203	ARAR	Establishes the requirements for determining the annual effective dose equivalent.	The standard for determining the annual effective dose equivalent is applicable to remediation waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Planned Special Exposures," 10 CFR 835.204	ARAR	Establishes the requirements for a planned special exposure, for a radiological worker to receive doses in addition to and accounted for separately from dose limits established by 10 CFR 835.202.	This standard is applicable to remedial actions conducted in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs, if exceptional circumstances arise that require a worker to receive dose in addition to the dose limits established by 10 CFR 835.202.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Determinations of Compliance for Non-Uniform Exposure of the Skin," 10 CFR 835.205	ARAR	Establishes requirements for assessing nonuniform exposures from X-rays, beta radiation, and/or radioactive material on the skin.	This standard for determining compliance for nonuniform exposure of the skin is applicable to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Limits for the Embryo/Fetus," 10 CFR 835.206	ARAR	Establishes the dose equivalent for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker as 0.5 rem. The standard also prevents a declared pregnant worker from being assigned to tasks where additional occupational exposure is likely during the remainder of the pregnancy.	Standards for occupational dose limits to an embryo/fetus of a declared pregnant worker are applicable to remediation waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Limits for Members of the Public Entering a Controlled Area," 10 CFR 835.208	ARAR	Establishes the total effective dose equivalent for members of the public exposed to radiation and/or radioactive material during access to a controlled area as 0.1 rem/yr.	Standards for occupational dose limits are applicable to remediation waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Concentrations of Radioactive Material in Air," 10 CFR 835.209	ARAR	Establishes the requirements for controlling occupational exposures to airborne radioactive material.	The standards for occupational dose limits are applicable to remediation waste sites in the TW-1, TW-2, and PW-5 OUs.
EPA Memorandum, *Radiation Risk Assessment at CERCLA Sites: Q & A*, EPA/540/ R-99/006, also OSWER Directive 9200.4-31P	TBC	Provides further guidance for conducting radiation risk assessments for evaluating cleanup levels at CERCLA sites. The EPA has determined in this directive that dose limits established by the NRC (25 mrem/yr) generally are not protective at CERCLA sites and instead states that a cleanup level of 15 mrem/yr is protective of human health and the environment. The EPA dose limits are to generally achieve risk levels in the 10^{-4} to 10^{-6} risk range.	This memorandum, although a TBC, is considered by the EPA to be more protective than NRC standards; therefore, it will be used at waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR 61			
"Protection of the General Population from Releases of Radioactivity," 10 CFR 61.41	ARAR	Requires that concentrations of radioactive materials that may be released to the general environment in groundwater, surface water, air, soil, or animals may not result in annual doses that exceed 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ. This regulation also requires that a reasonable effort be made to maintain releases of radioactivity in effluents in the general environment at levels as low as reasonably achievable.	The regulation is not applicable because it applies to land disposal of radioactive waste containing byproduct, source, and special nuclear material received from other persons; however, it is relevant and appropriate if radioactive waste will be left in place following remediation.
"Protection of Individuals from Inadvertent Intrusion," 10 CFR 61.42	ARAR	Requires that the design, operation, and closure of the land disposal facility ensure the protection of any individual who inadvertently intrudes into the disposal site, occupies the site, or contacts the waste at any time after active institutional controls over the disposal site have been removed.	Requirements to protect inadvertent intruders are relevant and appropriate to actions implemented at the site; inadvertent intruder scenarios are focused only on radionuclides.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Packaging and Transportation of Radioactive Material," 10 CFR 71			
"General Standards for All Packages," 10 CFR 71.43	ARAR	Establishes the packaging requirements for radioactive materials.	The regulations are applicable only for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not an NRC-licensed plant; however, potentially radioactive waste will be generated by remedial actions in the operable unit. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.
"Lifting and Tie-Down Standards for All Packages," 10 CFR 71.45	ARAR	Establishes the lifting and tiedown standard for radioactive material packages.	The regulations are applicable only for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not an NRC-licensed plant; however, potentially radioactive waste will be generated by remedial actions in the operable unit. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.
"External Radiation Standards for All Packages," 10 CFR 71.47	ARAR	Establishes the external radiation levels for packages of radioactive materials being offered for transportation.	The regulations are applicable only for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not an NRC-licensed plant; however, potentially radioactive waste will be generated by remedial actions in the operable unit. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.
Environmental Restoration Disposal Facility Waste Acceptance Criteria, BHI-00139	TBC	Establishes waste acceptance criteria for the Environmental Restoration Disposal Facility.	Criteria are important considerations for remove-and-dispose alternatives and for generation of waste during characterization or remedial activities that may identify the Environmental Restoration and Disposal Facility as the potential disposal location.
Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table B-2).			

10 CFR 20, "Standards for Protection Against Radiation."
10 CFR 61, "Licensing Requirements for the Land Disposal of Radioactive Waste."
10 CFR 71, "Packaging and Transportation of Radioactive Material."
10 CFR 835, "Occupational Radiation Protection."
40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards."
40 CFR 61, "National Emission Standards for Hazardous Air Pollutants."
40 CFR 141, "National Primary Drinking Water Standards."
40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions."
BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.
EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, OSWER Directive 9200.4-31P.
Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.
WAC 173-303, "Dangerous Waste Regulations."

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations.*
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NRC = U.S. Nuclear Regulatory Commission.
OU = operable unit.
PCB = polychlorinated biphenyl.
RCRA = *Resource Conservation and Recovery Act of 1976.*
TBC = to be considered.
WAC = *Washington Administrative Code.*

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Dangerous Waste Regulations," WAC 173-303			
"Identifying Solid Waste," WAC 173-303-016	ARAR	Identifies those materials that are and are not solid waste.	The requirements of this section are applicable to the onsite generation of waste in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because they identify those materials that are subject to the dangerous waste regulations. These regulations may be relevant and applicable to waste sites within the AOC.
"Recycling Processes Involving Solid Waste," WAC 173-303-017	ARAR	Identifies materials that are and are not solid wastes when recycled.	The requirements of this section are applicable to the onsite remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because they identify those materials that are subject to the dangerous waste regulations.
"References to EPA's Hazardous Waste and Permit Regulations," WAC 173-303-045	ARAR	Identifies those provisions of RCRA (40 CFR Parts 260 through 268 and Part 124) that are not incorporated by reference because they are provisions that the EPA cannot delegate to the states.	The requirements of this section are applicable to remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because they identify those sections of RCRA that the EPA cannot delegate to the states.
"Designation of Dangerous Waste," WAC 173-303-070	ARAR	Establishes the method for determining whether or not a solid waste is a dangerous waste or an extremely hazardous waste.	The requirements of this section are applicable because dangerous waste could be generated during remedial-action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of waste that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050).	The conditions of this requirement are applicable to remedial actions in the TW-1, TW-2, and PW-5 OUs, should waste. identified in WAC 173-303-071 be encountered.
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special waste, as defined in WAC 173-303-040.	The conditions of this requirement are applicable to remedial-action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs, should special waste be encountered.
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those waste types exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These waste types are subject to regulation under WAC 173-303-573.	The requirements of this section are applicable to universal wastes generated through the remediation activities of the waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Discarded Chemical Products," WAC 173-303-081	ARAR	Identifies when discarded products are to be designated as dangerous waste.	The requirements of this section are applicable to remediation activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs that may use a commercial chemical product.
"Dangerous Waste Sources," WAC 173-303-082	ARAR	Identifies the requirements for dangerous waste sources identified in WAC 173-303-9904.	This requirement is applicable to any waste or residue listed in WAC 173-303-9904, that was generated through remediation activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Dangerous Waste Criteria," WAC 173-303-100	ARAR	Establishes criteria for determining if a solid waste is a dangerous waste.	The criteria established in this section are applicable to waste generated through the remediation activities of the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Sampling and Testing Methods," WAC 173-303-110	ARAR	Establishes the testing method to be used to comply with the requirements of this chapter. This section also requires the use of control procedures for the analytical results.	The requirements of this section are applicable to sampling and testing methods used during sampling activities at the remedial action waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Recycled, Reclaimed, and Recovered Wastes," WAC 173-303-120	ARAR	Describes the requirements for recycling materials that are solid waste and dangerous waste.	Materials generated during site characterization or remedial action may be recyclable and not subject to all applicable dangerous waste requirements; therefore, this regulation is applicable to recyclable wastes that meet the criteria of WAC 173-303-120 in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Land Disposal Restrictions," WAC 173-303-140	ARAR	Incorporates by reference, EPA land disposal requirements in 40 CFR 268 that are applicable to wastes designated in accordance with WAC 173-303-070.	Incorporates by reference, land disposal restrictions applicable to dangerous waste that the EPA cannot delegate to the states; therefore, this regulation is applicable to the waste sites containing dangerous waste within the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Spills and Discharges into the Environment," WAC 173-303-145	ARAR	Sets forth the requirements that apply when any dangerous waste or hazardous substance is intentionally or accidentally spilled or discharged into the environment such that human health and the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance.	This regulation is applicable to onsite remedial activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs, should dangerous waste or hazardous substances be spilled or discharged into the environment. This regulation may be relevant and appropriate, should a dangerous waste be spilled or discharged within the AOC.
"Requirements for Generators of Dangerous Waste," WAC 173-303-170	ARAR	Establishes the requirements for dangerous waste generators.	The requirements of this section are applicable to actions performed at the site if dangerous waste is generated in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs. However, if waste is generated in an AOC, the requirements of WAC 173-303-170 are relevant and appropriate.
"Model Toxics Control Act – Cleanup," "Soil Cleanup Standards for Industrial Properties," WAC 173-340-745			
"Soil Cleanup Standards for Industrial Properties," WAC 173-340-745	ARAR	Identifies the methods used to identify risk-based concentrations and their use in the selection of a cleanup action. Cleanup and remediation levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest Federal or state cleanup criteria.	The risk-based concentrations for soils and protection of groundwater are relevant and appropriate to the 200-TW-1, 200-TW-2, and 200-PW-5 OUs waste site remedial actions.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Minimum Functional Standards for Solid Waste Handling," WAC 173-304			
"Owner Responsibilities for Solid Waste," WAC 173-304-190	ARAR	Requires the owner, operator, or occupant of any premise, business establishment, or industry to be responsible for the satisfactory and legal arrangement for solid waste handling and solid waste accumulation on the property.	The regulation is applicable to onsite management and accumulation of solid wastes generated in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"On-Site Containerized Storage, Collection and Transportation Standards for Solid Waste," WAC 173-304-200	ARAR	Establishes the standards for the storage of containerized solid waste generated on site.	This section is applicable to the onsite containerized storage, collection, and transportation of solid wastes that may be generated during remediation activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Solid Waste Handling Standards," WAC 173-350			
"On-Site Storage, Collection and Transportation Standards," WAC 173-350-300	ARAR	Establishes the requirements for the temporary storage of solid waste in a container on site and the collecting and transporting of the solid waste.	This newly promulgated rule is relevant and appropriate to the onsite collection and temporary storage of solid waste at the 200-TW-1, 200-TW-2, and 200-PW-5 OUs remediation waste sites because compliance with this regulation is phased for existing facilities.
"Minimum Standards for Construction and Maintenance of Wells," WAC 173-160			
WAC 173-160-161	ARAR	Identifies well planning and construction requirements.	This requirement is applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or waste. The requirements of WAC 173-160-161 through 173-160-381 (excluding 173-160-211, 173-160-251, 173-160-261, 173-160-361, 173-160-400, 173-160-420, 173-303-430, 173-160-440, 173-160-450, and 173-160-460) are applicable to groundwater well construction, monitoring, or injection of treated groundwater or waste in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
WAC 173-160-171	ARAR	Identifies the requirements for locating a well.	
WAC 173-160-181	ARAR	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
WAC 173-160-191	ARAR	Identifies the design and construction requirements for completing wells.	
WAC 173-160-201	ARAR	Identifies the casing and liner requirements for water supply wells.	
WAC 173-160-221	ARAR	Identifies the requirements for sealing materials.	
WAC 173-160-231	ARAR	Identifies the requirements for surface seals on water wells.	

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
WAC 173-160-241	ARAR	Identifies the requirements for formation sealing.	
WAC 173-160-271	ARAR	Identifies the special sealing standards for driven wells, jetted wells, and dewatering wells.	
WAC 173-160-281	ARAR	Identifies the construction standards for artificial gravel-packed wells.	
WAC 173-160-291	ARAR	Identifies the standards for the upper terminal of water wells.	
WAC 173-160-301	ARAR	Identifies the requirements for temporary capping.	
WAC 173-160-311	ARAR	Identifies the requirements for well tagging.	
WAC 173-160-321	ARAR	Identifies the standards for testing a well.	
WAC 173-160-331	ARAR	Identifies the method for keeping equipment and the water well free of contaminants.	
WAC 173-160-341	ARAR	Identifies the method for ensuring the quality of the well water.	
WAC 173-160-351	ARAR	Identifies the standards for the installation of a pump.	
WAC 173-160-371	ARAR	Identifies the standard for chemical conditioning.	
WAC 173-160-381	ARAR	Identifies the standard for decommissioning a well.	
WAC 173-160-400	ARAR	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
WAC 173-160-420	ARAR	Identifies the general construction requirements for resource protection wells.	
WAC 173-160-430	ARAR	Identifies the minimum casing standards.	
WAC 173-160-440	ARAR	Identifies the equipment cleaning standards.	
WAC 173-160-450	ARAR	Identifies the well sealing requirements.	
WAC 173-160-460	ARAR	Identifies the decommissioning process for resource protection wells.	
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040	ARAR	Establishes the general emission standards for emission units. Emission standards identified in other chapters for specific emission units will take precedence over the general emission standards of this section.	Requirements of this standard are applicable to remedial actions performed at the site that could result in the emission of hazardous air pollutants. Substantive standards established for the control and prevention of air pollution under this regulation are applicable to remedial actions that may be proposed at a site.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Emission Standards for Sources Emitting Hazardous Air Pollutants," WAC 173-400-075	ARAR	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, 40 CFR 61 and appendices.	Requirements of this standard are applicable to remedial actions performed at the site that could result in the emission of hazardous air pollutants. Substantive standards established for the control and prevention of air pollution under this regulation are applicable to remedial actions that may be proposed at waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.
"Controls for New Sources of Toxic Air Pollutants," WAC 173-460			
"Control Technology Requirements," WAC 173-460-060	ARAR	Requires that new sources of air emissions provide the emission estimates identified in this regulation.	The standard is relevant and appropriate to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because nonradioactive OU contaminants of concern are identified in the regulation as toxic air contaminants.
"Ambient Impact Requirement," WAC 173-460-070	ARAR	Requires that, when applying for a notice of construction, the owner/operator of a new toxic air pollutant source that is likely to increase toxic air pollutant emissions shall demonstrate that emissions from the source are low enough to protect human health and safety from potential carcinogenic and/or other toxic effects.	The standard is relevant and appropriate to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because nonradioactive OU contaminants of concern are identified in the regulation as toxic air contaminants.
"Class A Toxic Air Pollutants: Known, Probable and Potential Human Carcinogens and Acceptable Source Impact Levels," WAC 173-460-150	ARAR	Identifies Class A toxic air pollutants and known or probable carcinogens.	The standard is relevant and appropriate to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because nonradioactive OU contaminants of concern are identified in the regulation as toxic air contaminants.
"Class B Toxic Air Pollutants and Acceptable Source Impact Levels," WAC 173-460-160	ARAR	Identifies Class B toxic air pollutants and the acceptable source impact levels.	The standard is relevant and appropriate to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs because nonradioactive OU contaminants of concern are identified in the regulation as toxic air contaminants.
"Ambient Air Quality Standards for Particulate Matter," WAC 173-470			
"Ambient Air Quality Standards," WAC 173-470-100	ARAR	Sets maximum acceptable levels for particulate matter in the ambient air at 150 $\mu g/m^3$ over a 24-hour period or 60 $\mu g/m^3$ annual geometric mean. It also sets the 24-hour ambient air concentration standard for particles less than 10 µm in diameter (PM_{10}), which are set at 105 $\mu g/m^3$ and 50 $\mu g/m^3$ geometric mean.	This state-authorized requirement is applicable to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs that may emit particulate matter to the air.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Particle Fallout Standards," WAC 173-470-110	ARAR	Establishes the standard for particle fallout not to exceed 10 g/m²/ month in an industrial area or 5 g/m²/ month in residential or commercial areas. Alternative levels for areas where natural dust levels exceed 3.5 g/m²/ month are set at 6.5 g/m²/ month, plus background levels for industrial areas, and 1.5 g/m²/ month plus background in residential and commercial areas.	This state-authorized requirement is applicable to remedial actions in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs that may emit particulate matter to the air.
"Ambient Air Quality Standards and Emission Limits for Radionuclides," WAC 173-480			
"Ambient Standard," WAC 173-480-040	ARAR	Defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standards under 40 CFR 61, Subparts H and I, are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	Requirements of this standard are relevant and appropriate to remedial actions performed in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs that may emit radionuclides to the air.
"General Standards for Maximum Permissible Emissions," WAC 173-480-050	ARAR	Requires that emission units, at a minimum, make every reasonable effort to maintain radioactive material in effluents to unrestricted areas as low as reasonably achievable, using reasonably available control technology.	Requirements of this standard are relevant and appropriate to remedial actions performed in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs that may emit radionuclides to the air.
"Emission Standards for New and Modified Emission Units," WAC 173-480-060	ARAR	Requires that emission standards for new and modified emission units use best available radionuclide control technology.	Requirements of this standard are relevant and appropriate to remedial actions performed in the TW-1, TW-2, and PW-5 OUs that may emit radionuclides to the air.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Radiation Protection – Air Emissions," WAC 246-247			
"Standards," WAC 246-247-040	ARAR	Promulgates air emission limits for airborne radionuclide emissions as defined in WAC 173-480-040, 173-480-050, 173-480-060, and 40 CFR 61, Subparts H and I. The ambient air standards under WAC 173-480 require that the most stringent standard be enforced. Ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. The ambient standard in WAC 173-480 specifies that emission of radionuclides to the air must not cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. These standards specify emission monitoring requirements and the application of best available *radionuclide technology requirements*—found in WAC 246-247-120, Appendix B; and the application of "as low as reasonably achievable control technology" found in WAC 246-247-130, Appendix C.	This regulation is considered applicable because airborne radionuclides may be generated during remedial action activities in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants."

40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."

40 CFR 61, Subpart I, "National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H."

40 CFR 124, "Procedures for Decision making."

40 CFR 260 through 268 (Chapter I – "Environmental Protection Agency").

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

WAC 173-303, "Dangerous Waste Regulations."

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling."

WAC 173-340-745, "Model Toxics Control Act – Cleanup, "Soil Cleanup Standards for Industrial Properties."

WAC 173-350, "Solid Waste Handling Standards."

WAC 173-400, "General Regulations for Air Pollution Sources."

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants."

WAC 173-470, "Ambient Air Quality Standards for Particulate Matter."

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides."

WAC 246-247, "Radiation Protection – Air Emissions."

AOC = area of contamination.
ARAR = applicable or relevant and appropriate requirement.
CFR = *Code of Federal Regulations*.
EPA = U.S. Environmental Protection Agency.
OU = operable unit.
RCRA = *Resource Conservation and Recovery Act of 1976*.
TBC = to be considered.
WAC = *Washington Administrative Code*.

APPENDIX C

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

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CONTENTS

FIGURES

TABLES

TERMS

ALE	Fitzner-Eberhardt Arid Lands Ecology Reserve
BCG	biota concentration guide (see DOE-STD-1153-2002)
BDAC	Biota Dose Assessment Committee
bgs	below ground surface
BRMaP	*Hanford Site Biological Resources Management Plan* (DOE/RL-96-32)
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (also known as *Superfund*)
CFR	*Code of Federal Regulations*
CLARC	cleanup levels and risk calculations (see Ecology 94-145)
CLUP EIS	*Final Hanford Comprehensive land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F)
COPC	contaminant of potential concern
CSM	conceptual site model
CZ	core zone
DOE	U.S. Department of Energy
ECAP	Ecological Compliance Assessment Project
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FS	feasibility study
GENCH	general chemical
GENOR	general organic
GWP	groundwater protection
HHRA	human health risk assessment
HQ	hazard quotient
ID	identification
IRIS	Integrated Risk Information System
K_d	distribution coefficient
MCL	maximum contaminant level
NA	not available
NOAEL	no observed adverse effect level
OSWER	Office of Solid Waste Emergency Response
OU	operable unit
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PEF	particulate emissions factor
PEST	pesticide
RA	risk assessment
RAD_D	decayed radiological
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant or process)
RESRAD	RESidual RADioactivity (dose model)

RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
SAC	System Assessment Capability
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (code)
SVOA	semi-volatile organic analyte
SZ	shallow zone
TBP	tributyl phosphate
TIC	tentatively identified compound
TPH	total petroleum hydrocarbon
UCF	unit conversion factor
UCL	upper confidence limit
VF	volatilization factor
VOA	volatile organic analyte
WAC	*Washington Administrative Code*
WDNR	Washington Department of Natural Resources
WIDS	Waste Information Data System

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C1.0 INTRODUCTION

This appendix provides the results of the baseline human health risk assessment (HHRA) (Section C3.0) and screening-level ecological risk assessment (SLERA) (Section C4.0) for several analogous sites in the 200-TW-1 and 200-PW-5 Operable Units (OUs) at the Hanford Site. The risk assessments (RAs) for representative sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs were conducted as part of the remedial investigation (RI) activities and area reported in DOE/RL-2002-42, *Remedial Investigation Report for 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 OU).* As part of the 200-BP-1 RI, the 216-B-43 Crib, 216-B-44 Crib, 216-B-45 Crib, 216-B-47 Crib, 216-B-48 Crib, 216-B-49 Crib, and 216-B-50 Crib were investigated using boreholes. The data are reported in DOE/RL-92-70, *Phase I Remedial Investigation Report for the 200-BP-1 Operable Unit.* Data for the 216-B-26 Trench analogous site were independently developed. These waste sites have data sufficient to evaluate risks; therefore, this RA presents an analysis of the human health, ecological, and protection of groundwater risks associated with these seven sites. The other analogous waste sites in these OUs do not have sufficient data for site-specific analyses; therefore, they are evaluated using the analogous site approach described in Section 2.0 of this feasibility study (FS).

The 200-TW-1, 200-TW-2, and 200-PW-5 OUs are located in or near the 200 West and 200 East Areas, which contain waste management facilities and inactive irradiated fuel reprocessing facilities. The HHRA and ecological risk assessment (ERA) address pathways associated with shallow zone (0 to 4.6 m [0 to 15 ft] below ground surface [bgs]) for estimating human health and ecological risks and deep zone soil (from the surface to the water table) for evaluating protection of the groundwater from vadose zone contaminants.

This RA was performed to determine whether a potential for risk to human health and the environment exists under current and reasonably anticipated future site-use conditions. The results are used, in part, to determine whether remedial action may need further evaluation and to focus the FS.

C1.1 ORGANIZATION OF THE RISK ASSESSMENT

This RA consists of the following components:

- **Conceptual site model (CSM):** Identifies the pathways by which human and ecological exposures could occur.
- **HHRA:** Provides the results of the contaminant of potential concern (COPC) selection process, human exposure assessment, toxicity assessment, and risk characterization.
- **SLERA:** Provides the results of the SLERA.

C2.0 CONCEPTUAL SITE MODEL

The conceptual site model (CSM) identifies the means by which human or ecological receptors on or near the 200-TW-1 and 200-PW-5 waste sites could come into contact with chemicals in environmental media. The CSM addresses exposures that could result under current site conditions and from reasonably anticipated potential future uses for the site and the surrounding areas.

This CSM provides a current understanding of the sources of contamination, physical setting, and current and future land use, and identifies potentially complete human and ecological exposure pathways for the study area. Information generated during the remedial investigation/feasibility study (RI/FS) process has been incorporated into this CSM to identify potential exposure scenarios.

C2.1 ECOLOGICAL SETTING

Information about the ecological setting is presented in more detail in DOE/RL-2001-54, *Central Plateau Ecological Evaluation Report*. The environmental setting encompasses the terrestrial habitats within the area of the waste sites. The availability and quality of terrestrial habitats determine the wildlife types that can be present and the likelihood that wildlife uses the areas associated with the waste sites in the study area.

C2.1.1 Terrestrial Habitats and Vegetation at the 200-TW-1 and 200-PW-5 Operable Unit Waste Sites

Environmental monitoring has been an ongoing activity since the early days of the Hanford Site. The monitoring efforts continue today and a significant body of information exists about the ecology of the Central Plateau. The latest data collection efforts focused on the Central Plateau and the 200 Areas were conducted in 2000 and 2001. The information collected was compiled into DOE/RL-2001-54.

The Hanford Site is located within the Columbia Basin ecoregion, a nearly 6-million-hectare (14.8 million-acre) region once dominated by steppe and shrub-steppe vegetation (Franklin and Dyrness 1973, *Natural Vegetation of Oregon and Washington*). Today, an estimated 60% of the shrub-steppe habitat in Washington State has been converted to other uses by humans, as reported in TNC (1999), *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999*.

The habitats associated with the Central Plateau have been characterized, mapped, and described in recent years by WHC-SD-EN-TI-216, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*; TNC (1999); and documents produced by the Pacific Northwest National Laboratory (e.g., PNL-8942, *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*; PNNL-13230, *Hanford Site Environmental Report 1999*).

Institutional controls and limited access to the Hanford Site for nearly 60 years have preserved the shrub-steppe ecosystems in some areas, while other locations (e.g., at facilities and waste sites) are highly disturbed. The Hanford Site as a whole and the U.S. Department of Defense Yakima Training Center are considered significant parcels within the Columbia Basin ecoregion because they contain the largest remaining areas of relatively undisturbed shrub-steppe habitat

(Smith 1994, *Evaluating the Conservation of Avian Diversity in Eastern Washington: A Geographic Analysis of Upland Breeding Birds*; TNC 1999).

The shrub-steppe community present on the Hanford Site is characterized by three or four layers of vegetation, depending on its stage of succession: (1) an overstory composed mostly of big sagebrush (sagebrush) (*Artemisia tridentata*) (2) a tall understory (bluebunch wheatgrass [*Agropyron spicatum*]), (3) a short understory, often dominated by Sandberg's bluegrass (*Poa sandbergii*), and (4) the cryptogamic crust (i.e., algae, lichens, and mosses on the soil surface). On the Central Plateau outside of the perimeter fence lines of the industrialized 200 Areas, the native shrub-steppe habitat dominates except in areas that have been disturbed by waste disposal operations (e.g., large cooling-water disposal ponds) or by range fires. Big sagebrush does not resprout after fire (Young and Evans 1977, "Arrowleaf Balsamroot and Mules Ear Seed Germination"). Sagebrush must grow from seed and may take up to 15 years to return after a fire. Grasses, however, are more fire tolerant, and cheatgrass (*Bromus tectorum*) can assume dominance after a fire (West and Hassan 1985, "Recovery of Sagebrush-Grass Vegetation Following Wildlife"). Russian thistle (*Salsola kali*), an early successional annual species, also dominates recently disturbed soils. Disturbed areas associated with waste sites and range fires offer lower quality habitat and have low community diversity, whereas relatively undisturbed sagebrush-grassland shrub-steppe habitat supports a higher number of organisms (i.e., has the highest biodiversity).

Within the industrial area fence lines, approximately 19% of the area is shrub-steppe and is relatively undisturbed; however, most of this land has been designated for future operations, such as expansion of the Central Waste Complex and operation of the Immobilized Low-Activity Waste disposal facility. The disturbed industrial land within the fence lines is predominantly gravel, buildings, and roads, with little vegetation. The disturbed habitat supports a very limited number of organisms (i.e., has low biodiversity). Sensitive species rarely are present in the disturbed habitat associated with waste management.

In the native shrub-steppe habitat surrounding the 200 Areas, the most prevalent shrub is big sagebrush, and the understory is dominated by the native perennial Sandberg's bluegrass and cheatgrass. Other shrubs present in the Central Plateau include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*).

Large areas of disturbed ground dominated by annual grasses and herbaceous plants are present in the 200 Areas. Vegetation/habitat maps for the Central Plateau are provided in Appendix B of DOE/RL-2001-54. Disturbed and nonvegetated (gravel or asphalt) areas in the Central Plateau have minimal vegetative cover (<10%) (WHC-SD-EN-TI-216) and are primarily the result of either mechanical disturbance (e.g., from road clearing or facility construction) or range fires. The waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs have been highly disturbed and are either nonvegetated, graveled surfaces, or planted with wheatgrass.

In less disturbed parcels of shrub-steppe on the Hanford Site, the ground surface is covered with a fragile thin crust (cryptogamic crust), consisting of mosses, lichen, algae, and bacteria that protect the soil beneath. The cryptogamic crust prevents erosion, retains moisture, and provides nutrients within the surface soils. The cryptogamic crust is an integral component of the arid terrestrial ecosystem, and its disturbance compromises the succession of native species. In the absence of the cryptogamic crust, disturbed soils are vulnerable to invasion by non-native and weedy colonizing species. The principal colonizers of disturbed sites are non-native annual species, such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), and cheatgrass.

Mechanical disturbance typically results in the loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that recolonize a site. Many waste sites have been backfilled with clean soil and planted with crested (*Agropyron cristatum*) or Siberian wheatgrass (*Agropyron sibericum*) to stabilize the surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415, *Hanford Site National Environmental Policy Act [NEPA] Characterization*). Many interim-stabilized waste sites are treated with herbicide as needed to prevent the uptake of underground contamination by deep-rooted plants. These sites have varying levels of disturbance. Some waste sites are highly disturbed, consisting of a gravel surface; others have a light vegetative cover of grasses and herbaceous plants; and yet others exhibit varying degrees of succession supporting the growth of shrubs. The most common organisms inhabiting the waste site areas are ants, beetles, and mice. Ants tunnel underground and move soil to the surface. The ability of ants to move contaminants to the surface at the Hanford Site is not well documented. Biota samples in conjunction with soil samples would be helpful in understanding the completeness of this exposure pathway.

C2.1.1.1 Terrestrial/Avian Wildlife

The number and species of wildlife endemic to the Central Plateau have been evaluated in a number of sources, including ecological characterization reports (e.g., PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*; PNL-8942).

A recent Ecological Compliance Assessment Project (ECAP) survey of the Central Plateau evaluated the abundance and distribution of birds, small mammals (mice), reptiles, and invertebrate species. DOE/RL-2001-54, Table 2-3, summarizes the most common organisms observed or captured on the 200 Areas Central Plateau.

The largest mammal frequenting the Central Plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the Central Plateau make up a distinct group called the "central population" (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE). Occasionally a few elk have been observed south of the 200 Areas. However, the herd on the ALE recently was thinned; therefore, the elk are not expected to continue expanding their range into the Central Plateau.

Other mammals common to the Central Plateau are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Jackrabbits (*Lepus californicus*) also are present in low numbers in the 200 Areas. Badgers are known for their digging ability and have been suspected of excavating contaminated soil at Central Plateau radioactive waste sites (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area, USACE Hanford Reservation*). The majority of badger diggings are a result of searches for food, especially for other burrowing mammals such as pocket gophers and mice. Coyotes also are a top mammalian predator on the Hanford Site. They are opportunistic feeders and consume a variety of prey including mice, rabbits, birds, snakes, lizards, and insects, in addition to scavenging on carrion along roadways and eating fruit from agricultural fields. They are the most widely ranging mammals within the Central Plateau, with home territories ranging from 800 to 8,000 ha (0.3 to 30 mi^2). Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the Central Plateau, predominantly consume vegetation, and can excavate large amounts of soil as they construct their burrows (Hakonson et al. 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers"). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the Central Plateau include western meadowlarks (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), and western kingbirds (*Tyrannus verticalus*). Species associated with the industrialized portions of the Central Plateau include rock doves (*Columba livia*), starlings (*Sturnus vulgaris*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in abandoned badger or coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive Central Plateau waste sites. Recent characterizations of the Central Plateau have identified western meadowlarks as being the most widely distributed bird species, followed by horned larks and mourning doves (*Zenaida macroura*). Other conspicuous birds include terrestrial game birds (e.g., California quail [*Callipepla californica*], chukar [*Alectoris chukar*], ring-necked pheasant [*Phasianus colchicus*]), passerine species, and raptors (e.g., red-tailed hawk [*Buteo jamaicensis*], northern harrier [*Circus cyaneus*]).

Reptiles found in the Central Plateau include gopher snakes (*Pituophis melanoleucus*) and side-blotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Reptile sightings were not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 ECAP survey (DOE/RL-2001-54, Appendix B).

Three of the most common groups of insects found at the Hanford Site include darkling beetles, grasshoppers, and ants. Insect studies near waste management facilities have concentrated on these three major groups. PNL-2713, *Shrub-Inhabiting Insects of the 200 Area Plateau, Southcentral Washington* characterized the insects, including spiders, associated with major shrubs of the Central Plateau. Sagebrush, rabbitbrush, and hopsage were the three shrubs included in the study. Three areas were selected for collecting shrub-inhabiting insects: (1) near the B/C Cribs, (2) near the former Reduction Oxidation (REDOX) Facility pond area, and (3) in a controlled area located on the nearby ALE. PNL-2713 found that the seasonal pattern for insect abundance on rabbitbrush was bimodal, peaking in May or June and again in September and October. Darkling beetles are a dominant part of the insect community in the Central Plateau where they occur with very little seasonal restriction, but exhibit dramatic changes in abundance from year to year (PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*). Grasshoppers are herbivorous insects common in the Central Plateau. Their abundance cycles from year to year, with increased population size from May to July annually.

C2.1.2 Sensitive Habitats

Sensitive habitats include those identified as rare, wetland, or riparian. Sensitive habitats present on the Central Plateau include basalt outcrops, riparian areas, former wetland areas associated with historic liquid waste disposal, and vernal pools. Wetlands are protected by the Federal government under the *Clean Water Act of 1977* (Section 404) and the state government

("Washington Water Pollution Control" and *Washington Administrative Code* [WAC] 173-20, "Shoreline Management Act – Lakes Constituting Shorelines of the State"). None of the 200-TW-1, 200-TW-2, or 200-PW-5 OU waste sites are associated with these types of sensitive habitats.

C2.1.3 Sensitive Species and Species of Concern

Sensitive species include threatened and endangered species, which are protected by Federal and state laws. Washington State defines sensitive species as any wildlife species native to the State of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats (WAC 232-12-297, "Permanent Regulations," "Endangered, Threatened, and Sensitive Wildlife Species Classification," defines the term "sensitive"). Species of concern are those that do not have a Federal designation but that may warrant additional protection because they are rare or stressed. None of the following sensitive species or species of concern has been identified associated with the waste sites in these OUs.

C2.1.3.1 Threatened and Endangered Species

Threatened and endangered species are plants and animals that are few in number and are protected by Federal regulations (50 *Code of Federal Regulations* [CFR] 17, "Endangered and Threatened Wildlife and Plants"). An "endangered" species is one that is in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered in the foreseeable future. The Federal *Endangered Species Act of 1973* requires conservation of threatened and endangered species.

Two federally protected species have been observed at the Hanford Site, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species also are protected under the *Migratory Bird Treaty Act*.

No plants, invertebrates, amphibians, reptiles, or mammals are on the Federal or Washington State threatened and endangered species lists.

C2.1.3.2 Rare Plants

Rare plant species refer to any vascular plant species listed by the Washington Natural Heritage Program (1998) as endangered, threatened, or sensitive in Washington State. Beyond threatened and endangered species, the Washington Department of Natural Resources (WDNR) Natural Heritage Program and the Washington Department of Fish and Wildlife have prioritized the conservation of additional species. Data are available on state and global rarity, endemic species, and the resource level of concern to which the species is assigned at the Hanford Site. The list of species of concern, as presented in DOE/RL-96-32 (*Hanford Site Biological Resources Management Plan*) (BRMaP), is lengthy. The Nature Conservancy survey discovered 112 populations of 28 rare plant taxa on the Hanford Site (TNC 1999). Although rare plants were found dispersed throughout the Site, the highest densities occurred on the east end of Umtanum Ridge, the basalt-derived sands near Gable Mountain, the White Bluffs, Rattlesnake Mountain, and Yakima Ridge.

C2.1.3.3 Mammalian Species of Concern

Pygmy rabbit (*Brachylagus idahoensis*). Pygmy rabbits dig simple burrows in soil. They generally are found within a 30-m (98-ft) radius of their burrows during winter and expand their home range in spring and summer. The pygmy rabbit depends primarily on dense stands of big sagebrush for food and cover. The Idaho pygmy rabbits' diet consists largely of sagebrush in the winter, with grasses (39%) and forbs (10%) added in spring and summer.

C2.1.3.4 New-to-Science Species

The Nature Conservancy conducted a biodiversity survey of plants, mammals, reptiles, and amphibians, birds, and insects at the Hanford Site between 1994 and 1998 (TNC 1999). This survey found two species and one variety of plants and 41 species and two subspecies of insects that had not been known to science. Umtanum desert buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Lesquerella tuplashensis*) and a new variety, basalt milk vetch (*Astragalus conjunctus* var. *rickardii*), were identified as new plant species. The new plant and insect species are listed at http://www.pnl.gov/ecomon/species/species.html.

U.S. Fish and Wildlife and Washington State have not yet determined the protective status of these new-to-science species (i.e., whether or not they are considered threatened or endangered). The BRMaP offers guidance for the protection of most of these species. Rare plants were found dispersed throughout the Site; however, the highest densities occurred on the east end of Umtanum Ridge, the basalt-derived sands near Gable Mountain, the White Bluffs, Rattlesnake Mountain, and Yakima Ridge. Each vernal pool cluster contained one or more rare plants. The new-to-science plants and their habitat requirements are described in the following paragraphs.

Umtanum desert buckwheat (*Eriogonum codium*). The only known population of Umtanum desert buckwheat consists of approximately 5,200 plants on Umtanum Ridge in Benton County at the western edge of the Hanford Site. Umtanum desert buckwheat is a long-lived (possibly more than 100 years), extremely slow-growing, woody perennial that forms low mats (Dunwiddie et al. 2001, "Demographic Studies of *Eriogonum codium* Reveal, Caplow & Beck (Polygonaceae) in Washington," *Conservation of Washington's Rare Plants and Ecosystems, Proceedings from a Conference of the Rare Plant Care and Conservation Program of the University of Washington*; and TNC 1998, *Biodiversity Inventory and Analysis of the Hanford Site, 1997 Annual Report*). This singular population is restricted to a narrow, scattered distribution within a 1.6-km (1-mi) portion of Umtanum Ridge (Dunwiddie et al. 2001) and is not located near any of the waste sites considered here. The species grows exclusively on exposed basalt flow material of the Lolo Flow of the Wanapum basalt formation. The soils are classified as lithosols and are composed of fine reddish to blackish basalt overlain with pumice. Researchers from The Nature Conservancy have observed western harvester ants (*Pogonomyrmex occidentalis*) gathering mature Umtanum desert buckwheat seeds.

White Bluffs bladderpod (*Lesquerella tuplashensis*). White Bluffs bladderpod is a short-lived perennial that grows on the upper edge of the White Bluffs of the Columbia River in Franklin County, not near any of the waste sites considered here. The single known population of the species varies considerably between years, but censuses of adult (flowering) plants suggest more than 50,000 plants may be present during some years (TNC 1998). The plant is found in a near-vertical exposure of cemented, highly alkaline calcium carbonate paleosol (a "caliche" soil). This hard calcium carbonate paleosol caps several hundred feet of alkaline, easily eroded lacustrine sediments of the Ringold Formation. The species occurs intermittently in a narrow band (usually less than 10 m [33 ft] wide) along an approximately 17-km (10.6-mi) stretch of the bluff.

Basalt milk vetch (*Astragalus conjunctus* var. *rickardii*). Basalt milk vetch typically is associated with bunchgrass areas within big sagebrush-steppe communities. It has been found on the top and north end of Rattlesnake Mountain at the Hanford Site (TNC 1999). The basalt milk vetch has not been identified near any 200 Areas waste sites. The other known population of basalt milk vetch in Benton County is a small population on the Chandler Butte portion of the Horse Heaven Hills. This represents a more northern extension of the plant's range than had been known previously.

New-to-science insect species also were identified. The Nature Conservancy identified 2 beetles (*coleoptera*), 9 flies (*diptera*), 5 leaf-hoppers (*homoptera*), 7 bees, ants, and wasps (*hymenoptera*), and 20 butterflies and moths (*lepidoptera*) on the Hanford Site (TNC 1999). The insects were dispersed throughout the Site, with the new species found in shrub-steppe, areas around the basalt talus, springs, and upland areas. Early results indicated that the insects found in disturbed areas were strikingly different from those found in areas with relatively intact shrub-steppe habitat. Both the type of insects found and the timing of insect activity varied between the two habitats. For example, more scorpions were noted in the shrub-steppe than in disturbed habitats. Also of note was the uniqueness of the insects surrounding West Lake. None of the new-to-science insects would be expected on or near the 200-TW-1, 200-TW-2, or 200-PW-5 OU waste sites.

Based on the information about the habitat and wildlife in the Central Plateau, three primary areas of consideration are important to the decision-making process.

- The shrub-steppe habitat at the Hanford Site is one of the largest parcels of shrub-steppe in a region where the availability of this habitat is declining. Protection of shrub-steppe habitat at the Hanford Site is critical for the health of the regional ecosystem. The shrub-steppe habitat on the Hanford Site also provides for the most diverse community of plants and animals in the arid upland environment, and diverse communities are better able to cope with environment stresses, such as contamination, than uniform communities.
- Individual species, whose populations are limited and are designated as sensitive species, must be protected.
- Most waste sites on the Central Plateau of the Hanford Site are disturbed habitats covered with gravel or grasses and other small plants. These sites have a very low biodiversity of floral and faunal species and offer poor quality habitat for animals. Additionally, succession of native species has been slow in these disturbed areas. Recovery of disturbed habitats to a mature shrub-steppe community is estimated to take more than 100 years if left alone.

Because of the disturbance of the waste sites, little to no habitat exists at the present. Many of the waste sites in these OUs are located below 4.6 m (15 ft) bgs and would pose little threat to ecological receptors in the area. One important characteristic of the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites is the presence of salts in the waste streams that were discharged to the soil. Historically, these salts have attracted animals, which has resulted in the release of contaminants to the environment when these animals burrowed into the waste sites to access them.

C2.2 CHARACTERIZATION OF LAND USE

The land-use boundary around the 200 East and 200 West Areas has been designated as industrial (exclusive) in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (CLUP EIS). All waste sites are located within the industrial (exclusive) land-use boundary (core zone).

Land use within the core zone of the 200 Areas is currently considered industrial (exclusive) and is defined as "preserving U.S. Department of Energy (DOE) control of the continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed waste treatment, and storage and disposal facilities" (DOE/EIS-0222-F). The waste sites inside the core zone meet the definition of an industrial property under WAC 173-340-200, "Model Toxics Control Act – Cleanup," "Definitions," and WAC 173-340-745, "Model Toxics Control Act – Cleanup," "Soil Cleanup Standards for Industrial Properties," by meeting the following criteria: the waste sites do not serve as current residential areas, they have no potential to serve as future residential areas, access to the industrial property by the general public is not allowed or access is highly limited and controlled to address safety or security considerations, and food is not grown or raised on the property.

Future land use at the Hanford Site is uncertain; however, DOE, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (i.e., Tri-Parties) have agreed that an industrial scenario will be used to evaluate waste sites within the core zone. Other scenarios have also been run to provide additional information to decision makers. Land use is described in more detail in Section 3.0 of the FS.

C2.3 GROUNDWATER BENEFICIAL USE

Local groundwater is not a current source of drinking water in the core zone. In addition, groundwater beneath the core zone is not anticipated to become a future source of drinking water until groundwater cleanup levels are met. Under current conditions, no complete human exposure pathways to groundwater are assumed at the waste sites. Risks associated with current contamination in the groundwater were not evaluated in this FS. Contaminated groundwater in the 200 East Area is being and will continue to be addressed under the 200-BP-5 and 200-PO-1 Groundwater OUs. Contaminated groundwater in the 200 West Area is being and will continue to be addressed under the 200-UP-1 and 200-ZP-1 Groundwater OUs.

The potential for contaminants to migrate from the soil to groundwater was evaluated in the risk evaluation. Concentrations in soil were compared to groundwater protection risk-based standards for the nonradiological constituents. For radiological constituents, the RESidual RADioactivity (RESRAD) (ANL 2002, *RESRAD for Windows*, Version 6.21) output provided current and future simulations of contribution to the risk of groundwater contamination from the movement of vadose contaminants to groundwater. Fate and transport modeling using the *Subsurface Transport Over Multiple Phases* (STOMP) code was not conducted because these sites are analogous to the representative site 216-B-46 Crib, where groundwater protection has been established as required (PNNL-11216, *STOMP – Subsurface Transport Over Multiple Phases: Application Guide).*

C2.4 CONCEPTUAL EXPOSURE MODEL FOR HUMAN HEALTH AND THE ENVIRONMENT

This Section describes the potential exposure pathways from site contaminants, based on currently available site information. The conceptual exposure model is formulated according to guidance (EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual [Part E, Supplemental Guidance for Dermal Risk Assessment]*), with the use of professional judgment and information on contaminant sources, release mechanisms, routes of migration, potential exposure points, potential routes of exposure, and potential receptor groups associated with the waste site.

An exposure pathway can be described as the physical course that a COPC takes from the point of release to a receptor. Chemical intake or exposure route is the means by which a COPC enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A source
- A mechanism for chemical release and transport
- An environmental transport medium
- An exposure point
- An exposure route
- A receptor or exposed population.

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, no risk or hazard exists. Figure C-1 presents the conceptual exposure model for the waste site.

C2.4.1 Contaminant Sources

The primary sources of contaminants at the six representative waste sites are described in the RI.

C2.4.2 Release Mechanisms and Environmental Transport Media

The primary release mechanisms transporting the COPCs from the source, via environmental media, to potential receptors include the following:

- Infiltration, percolation, and leaching of contaminants from waste sites to groundwater
- Direct contact with shallow zone soil containing COPCs (receptor contact with onsite shallow zone soil replaces release and transport)
- Generation of dust emanating from shallow zone soil to ambient air from wind or during maintenance or construction activities at the waste site
- Volatilization of chemicals emanating from shallow zone soil to ambient air at the waste site.

C2.4.3 Potentially Complete Human Exposure Pathways and Receptors

Based on the current understanding of land-use conditions at and near the waste site, as represented in Figure C-1, the most plausible exposure pathways that are considered for characterizing human health risks are described in the following paragraphs.

The industrial land-use scenario is the baseline for evaluation in this FS. To provide additional information to decision makers, a Native American exposure scenario is presented.

For the purposes of this RA, the point of compliance for shallow zone soils is defined as 0 to 4.6 m (0 to 15 ft) bgs and is evaluated using soil samples collected in this zone. This depth range is a reasonable estimate of the depth of soil that could be excavated and distributed to the surface as a result of development activities. The point of compliance for deep zone soils is defined as those samples collected throughout the soil profile (i.e., from the surface to the water table) and used to evaluate the protection of groundwater pathways.

Evaluation of the radiological constituents in shallow zone soil (for the direct-contact exposure pathways) was conducted using two different methods. The first evaluation method is considered representative of current waste site conditions because it accounts for a depth of clean cover over the waste site. The shielding effects of the clean cover influence the resulting dose and risk estimates. The second evaluation method is considered representative of worst-case conditions; it assumes that no clean cover is present over the top of the representative site (i.e., the exposure point concentration [EPC] is representative of the entire shallow zone).

C2.4.3.1 *Industrial Land-Use Scenario*

Under current and future waste site conditions, onsite industrial workers potentially could be exposed to shallow zone soils from the waste site. The industrial land-use scenario assumes that no groundwater from the waste site will be used for drinking purposes. Standard WAC 173-340-745, Method C soil risk-based standards for nonradiological constituents consider exposure through the direct-contact pathway (incidental soil ingestion and dermal contact) and inhalation of dust and vapors in ambient air. For radiological constituents, potential routes of exposure to shallow zone soil include external gamma radiation, incidental soil ingestion, and inhalation of dust particulates (Section C3.3.1 discusses the RESRAD model).

C2.4.3.2 Hypothetical Native American Subsistence Scenario

The DOE remains committed to considering Tribal exposure scenarios for conducting the RAs necessary to evaluate whether Hanford Site cleanup alternatives are protective of human health and the environment (Roberson 2002, "Hazard Categorization of EM Inactive Waste Sites as Less Than Hazard Category 3"). The Tri-Parties have interacted with the stakeholder Tribes over the past several years to obtain their input on developing a Native American exposure scenario or scenarios, including key parameters for the Central Plateau RA models.

The Tribes were involved in the RA framework workshops during the summer of 2002, and in October 2002, they were asked to provide written suggestions on specific RA parameters (exposure assumptions) for Tribal-use scenarios (DOE-RCA-2002-0584, 2002a, Letter [no title; topic: Tribal Input on CERCLA Risk Assessment], to Richard Gay, Confederated Tribes of the Umatilla Indian Reservation, from the Tri-Party Agreement signatories; DOE-RCA-2002-0584, 2002b, Letter [no title; topic: Tribal Input on CERCLA Risk Assessment], to Russell Jim, Confederated Tribes and Bands of the Yakama Nation, from the Tri-Party Agreement signatories; DOE-RCA-2002-0584, 2002c, Letter [no title; topic: Tribal Input on CERCLA Risk Assessment], to Patrick Sobotta, Nez Perce Tribe, from the Tri-Party Agreement signatories). This request culminated in a workshop in December 2002 that included Ecology, EPA, and DOE and representatives from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe. The Yakamas and the Nez Perce participated in the workshop but felt they needed additional time to provide input. The Umatillas asked that the information from "A Native American Exposure Scenario" (Harris and Harper 1997) be used to calculate risk estimates for a Native American subsistence scenario. The information from this study was used to estimate potential risks to a Native American from radiological constituents.

The Native American subsistence scenario proposed in Harris and Harper (1997) represents a "typical" Native American culture that incorporates the use of the entire Columbia Basin for food, water, and shelter. This hypothetical scenario was evaluated to provide a basis of comparison (assuming unrestricted land use) to the site-specific scenario (i.e., industrial) previously described. Considerable uncertainty is associated with applying the Native American subsistence exposure assumptions to each waste site and applying these assumptions likely overestimates the dose and risk associated with each waste site. Less uncertainty would be associated with risk estimates predicted on an area-wide basis, such as through the System Assessment Capability (SAC) process.[1]

C2.4.3.3 Protection of Groundwater

Constituents currently present throughout the soil column could potentially leach into groundwater beneath the waste site. Soil concentrations of nonradiological constituents protective of groundwater risk-based standards were calculated for the unrestricted land-use scenario. For radiological constituents, future impacts to the groundwater ingestion pathway were evaluated.

C2.4.4 Potentially Complete Ecological Exposure Pathways and Receptors

On the basis of the current understanding of land-use conditions (industrial land use) at these waste sites and the surrounding habitat, the following ecological exposures potentially associated with the study area waste sites will be considered for characterizing ecological risks:

- Direct contact with, or ingestion of, surface soil by avian (e.g., western meadowlark) and terrestrial (e.g., coyote) wildlife that might use the waste sites
- Bioaccumulation through ingestion of food items (e.g., plants or prey) consumed by wildlife that might forage at the waste sites.

C2.4.5 Computation of Exposure Point Concentrations

The EPCs are estimated chemical concentrations that a receptor could come in contact with and are specific to each exposure medium (i.e., shallow and deep zone soils). For the direct-contact routes of exposure, EPCs are represented by concentrations directly measured in soil. For the inhalation route, modeling was performed to estimate constituent concentrations in air from particulate or vapor emissions from soil.

[1] The hypothetical Native American subsistence scenario likely will be an iterative process and will become refined in the future through the RI/FS and Site cleanup processes.

C2.4.5.1 Direct-Contact Exposure Point Concentrations

The EPCs were calculated using the best statistical estimate of an upper bound on the average exposure concentrations, in accordance with WAC 173-340-745(8), "Model Toxics Control Act – Cleanup," "Soil Cleanup Standards for Industrial Properties," "Compliance Monitoring." As stated in EPA PB-96-3373, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, the 95% upper confidence limit (UCL) on the mean is considered a conservative upper bound estimate that is not likely to underestimate the mean concentration and most likely overestimates that concentration. The maximum detected concentration was used in place of the 95% UCL when the calculated 95% UCL was greater than the maximum detected value.

C2.4.5.2 Ambient Air Exposure Point Concentrations

Air concentrations were estimated by modeling particulate or vapor emissions from the soil. Air concentrations from vapor emissions were estimated using a volatilization factor for those constituents that are considered volatile. Volatile constituents considered for the inhalation pathway are operationally defined as those constituents with a Henry's Law constant greater than 10^{-5} atm-m^3/mole and a molecular weight less than 200 g/mole (EPA 2002, *Region 9 [Preliminary Remediation Goals] PRGs 2002 Tables* at www.epa.gov/region09/waste/sfund/prg/files/02table.pdf). Air concentrations from fugitive dust emissions were estimated using a particulate emissions factor for those constituents that are not volatile. The following equation was used to estimate air concentrations from volatile or particulate emissions:

$$Air\ Concentration = C_s \times \left(\frac{1}{PEF}\ or\ \frac{1}{VF} \right)$$

where

C_s = soil concentration (mg/kg)

VF = volatilization factor (chemical-specific) (m^3/kg)

PEF = particulate emissions factor (1.32×10^9 m^3/kg).

The volatilization factors for volatile organic compounds identified as COPCs in shallow zone soil[2] and the particulate emissions factor used to estimate fugitive dust emissions were obtained from EPA/540/R-96/018, *Soil Screening Guidance: Users Guide*.

C3.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the HHRA for the 200-TW-1 and 200-PW-5 analogous waste sites. The RA for the representative sites is contained in the RI report. This HHRA presents information about the analogous sites. This HHRA comprises the following components:

- **HHRA guidance:** Lists the guidance documents used for the HHRA.
- **Selection of COPCs:** Identifies the constituents considered to be most important to the evaluation of human health risk.

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[2] Shallow zone soils are defined as those collected from zero to 4.6 m (15 ft) bgs.

- **Human exposure and toxicity assessment:** Identifies the pathways by which potential human exposures could occur; describes how they are evaluated; and evaluates the magnitude, frequency, and duration of these exposures. Identifies the sources of toxicity values used.
- **RA results:** Integrates information from the exposure and toxicity assessments to characterize the risks to human health from potential exposure to contaminants in environmental media.
- **Identification of major uncertainties and assumptions:** Summarizes the basic assumptions used in the RA, as well as limitations of data and methodology.

C3.1 HUMAN HEALTH GUIDANCE

The procedures used for the HHRA are consistent with those described in WAC-173-340 and the following DOE and EPA guidance documents:

- EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume I – Human Health Evaluation Manual, Part A* (interim final)
- Office of Solid Waste Emergency Response (OSWER) Directive 9285.6-03, *Risk Assessment Guidance for Superfund, Vol. I, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, (Interim Final)*
- EPA/600/P-95/002Fa, *Exposure Factors Handbook*
- EPA/600/P-92/003C, *Proposed Guidelines for Carcinogen Risk Assessment*
- EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*
- EPA PB-96-3373, *Supplemental Guidance to RAGS: Calculating the Concentration Term.*

C3.2 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

The COPCs are those contaminants that should be carried through the human health risk quantification process. This component of the HHRA process summarizes those contaminants detected in environmental media and identifies the COPCs for environmental media that are accessible for human exposure. During the course of the HHRA, the COPCs are evaluated to identify and prioritize those contaminants that are estimated to pose an unacceptable risk and should be addressed by the FS.

C3.2.1 Data Used for Contaminant of Potential Concern Selection

Data evaluated for the analogous sites in this RA, except for the 216-B-26 Trench, include shallow[3] and deep zone soil samples collected during the 200-BP-1 RI (DOE/RL-92-70, *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*). The 216-B-26 Trench data were obtained after the 200-BP-1 RI with samples from a single borehole. The sources of analytical

[3] Shallow zone soils are defined as those collected from zero to 4.6 m (15 ft) bgs.

data used in this RA are summarized in Section 3.0 of the main document. Table C-1 summarizes all the samples included in this RA by station identification, sample identification, depth interval, and date of collection, except for the 216-B-26 Trench, which is summarized in Tables C-70 and C-71. The following rules were used to identify the data to be used in the RA:

- Estimated values flagged with a "B" (inorganics only) or "J" qualifier were treated as detected concentrations.
- Data qualified as rejected (flagged "R") were not used in the RA.
- Only the parent sample result was included in the analysis when field duplicate or split samples were collected.
- All radioisotopic data were decayed to 2004 conditions.

C3.2.2 Criteria for Selection of Contaminants of Potential Concern for the Human Health Risk Assessment

In accordance with the EPA, Ecology, and DOE guidance, factors considered in identifying the COPCs for the study area are as follows:

- Identification of detected chemicals
- Frequency of detection
- Essential nutrients
- Background screening
- Availability of toxicity values for use in calculating risk-based standards.

The COPCs were identified separately for shallow zone and deep zone soil samples from each waste site. Evaluation of the RA data using these criteria is discussed in the following subsections.

C3.2.2.1 Identification of Detected Chemicals

As a conservative measure, all chemicals that were detected at least once in any of the shallow zone or deep zone soil samples were carried to the next step in the COPC selection process. Chemicals that were not detected in any of the soil samples (i.e., 0% frequency of detection) were not selected as COPCs.

Because of the limited suite of data collected for the 216-B-26 Trench, summary statistics are not available for this trench. Maximum detected concentrations were used for the 216-B-26 Trench. A summary of significant shallow zone contaminants are presented in Table C-70.

C3.2.2.1.1 Shallow Zone[4]

The summary statistics for all radiological and nonradiological chemicals detected in shallow zone soil samples at least once are presented in Tables C-2 through C-8.

- **216-B-43 Crib:** A total of 23 nonradiological constituents and 10 radiological constituents were detected at least once in shallow soil.
- **216-B-44 Crib:** A total of 26 nonradiological constituents and 8 radiological constituents were detected at least once in shallow soil.

[4] Shallow zone soils are defined as those collected from zero to 4.6 m (15 ft) bgs.

- **216-B-45 Crib:** A total of 27 nonradiological constituents and 9 radiological constituents were detected at least once in shallow soil.
- **216-B-47 Crib:** A total of 24 nonradiological constituents and 7 radiological constituents were detected at least once in shallow soil.
- **216-B-48 Crib:** A total of 21 nonradiological constituents and 7 radiological constituents were detected at least once in shallow soil.
- **216-B-49 Crib:** A total of 23 nonradiological constituents and 7 radiological constituents were detected at least once in shallow soil.
- **216-B-50 Crib:** A total of 19 nonradiological constituents and 9 radiological constituents were detected at least once in shallow soil.

C3.2.2.1.2 Deep Zone

The summary statistics for all radiological and nonradiological chemicals detected in deep zone soil samples at least once are presented in Tables C-9 through C-15. Summary statistics were not available for the 216-B-26 Trench. A summary of significant deep zone contaminants are presented in Table C-71.

- **216-B-43 Crib:** A total of 49 nonradiological constituents and 14 radiological constituents were detected at least once in deep soil.
- **216-B-44 Crib:** A total of 49 nonradiological constituents and 13 radiological constituents were detected at least once in deep soil.
- **216-B-45 Crib:** A total of 49 nonradiological constituents and 13 radiological constituents were detected at least once in deep soil.
- **216-B-47 Crib:** A total of 45 nonradiological constituents and 11 radiological constituents were detected at least once in deep soil.
- **216-B-48 Crib:** A total of 50 nonradiological constituents and 12 radiological constituents were detected at least once in deep soil.
- **216-B-49 Crib:** A total of 37 nonradiological constituents and 13 radiological constituents were detected at least once in deep soil.
- **216-B-50 Crib:** A total of 25 nonradiological constituents and 13 radiological constituents were detected at least once in deep soil.

C3.2.2.2 Frequency of Detection

Constituents detected in shallow zone or deep zone soil samples at a frequency of 5% or more were carried to the next step of the screening process. In addition, constituents detected at a frequency of less than 5%, but with maximum concentrations greater than 10 times the soil risk-based standard, were retained as COPCs. Frequency statistics are not available for the 216-B-26 Trench.

C3.2.2.2.1 Shallow Zone[5]

The frequency-of-detection screening results for shallow soils are summarized as follows.

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[5] Shallow zone soils are defined as those collected from zero to 4.6 m (15 ft) bgs.

- **216-B-43 Crib.** As shown in Table C-2, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-44 Crib.** As shown in Table C-3, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-45 Crib.** As shown in Table C-4, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-47 Crib.** As shown in Table C-5, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-48 Crib.** As shown in Table C-6, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-49 Crib.** As shown in Table C-7, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-50 Crib.** As shown in Table C-8, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.

C3.2.2.2.2 Deep Zone

The frequency-of-detection screening results for deep soils are summarized as follows.

- **216-B-43 Crib.** As shown in Table C-9, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-44 Crib.** As shown in Table C-10, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-45 Crib.** As shown in Table C-11, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-47 Crib.** As shown in Table C-12, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-48 Crib.** As shown in Table C-13, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-49 Crib.** As shown in Table C-14, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.
- **216-B-50 Crib.** As shown in Table C-15, no constituents were detected at a frequency of less than 5%; therefore, all constituents were carried forward into the next screening step.

C3.2.2.3 Essential Nutrients

Essential nutrients are those constituents considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NAS 1989, *Recommended Dietary Allowances*). Because aluminum, calcium, iron, magnesium, potassium, and sodium are considered to be essential nutrients and have no available toxicity factors, they were excluded from further consideration as COPCs.

C3.2.2.4 Background Screening

The next criterion for identifying a constituent as one of potential concern was its presence at a concentration higher than naturally occurring levels. Sitewide soil background levels have been established for metals and radiological constituents for the Hanford Site. The statewide soil background level was used as the background level for cadmium. Sitewide and statewide soil background levels are not available for antimony, bismuth, cyanide, nitrite, selenium, sulfate, thallium, cobalt-60, plutonium-239, technetium-99, and tritium. If these metals or radionuclides were detected, they were carried forward into RA. Because volatile organic compounds, polychlorinated biphenyls (PCBs), and semi-volatile organic compounds are not naturally occurring in the soils at the Hanford Site, any constituent detected in these fractions also were carried forward into RA.

The maximum detected concentrations of each metal or radionuclide detected in shallow or deep zone soil were compared to the 90^{th} percentile background value. Summaries of metals and radiological constituents compared to background values for each representative waste site are provided in Tables C-16 through C-22 and C-70 for shallow zone soils and Tables C-23 through C-29 and C-71 for deep zone soils.

C3.2.2.5 Availability of Toxicity Values

If a toxicity value was not available from a reliable source or an appropriate surrogate could not be identified, then the chemical was not included in the RA. Toxicity values were identified for all COPCs in soil, with the exception of 2-ethyl-1-hexanol, 2-methyl propanoic acid, 6-methyl-dodecane, dodecane, heptadecane, hexadecane, hexadecanoic acid, pentadecane, tetradecane, tributyl phosphate, tridecane,4-methyl-tridecane, triphenyl-phosphine oxide, 2,6-dimethyl-undecane, and general chemical parameters (including chloride, fluoride, phosphate, sulfate, and total organic carbon). Toxicity values were generally unavailable for general chemical parameters, polyaromatic hydrocarbons (PAHs), and those constituents considered to be tentatively identified compounds (TICs). These constituents are, in general considered relatively nontoxic (e.g., general chemical parameters), were detected at a relatively low frequency (e.g., TICs) or correlate with the detection of chemicals that do have available toxicity values (e.g., PAHs). Therefore, these constituents were not carried forward into the RA; the exclusion of these constituents from this RA potentially could cause risk at the waste site to be underestimated.

C3.2.2.6 Contaminants of Potential Concern

Table C-30 summarizes the COPCs for the 216-B-43, 216-B-44, 216-B-45, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs. Table C-70 and C-71 summarize the significant COPCs for the 216-B-26 Trench.

C3.3 HUMAN EXPOSURE ASSESSMENT

The exposure assessment component of the HHRA identifies the populations that could be exposed, the routes by which these individuals could become exposed, and the magnitude, frequency, and duration of potential exposures. The human exposure assessment includes the following components:

- Discussion of the RESRAD RA methodology
- Development of exposure assumptions for potentially complete exposure pathways
- Calculation of chemical intake for COPCs
- Source of toxicity values.

C3.3.1 Residual Radioactivity Risk Assessment Methodology

The RA for radiological constituents was performed using RESRAD Version 6.2 analysis (ANL 2002). The RESRAD model was used to obtain risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone of the 200-TW-1 and 200-PW-5 analogous waste sites with data. The RESRAD model also was used to obtain risk and dose estimates for protecting the groundwater pathway. The results obtained from the RESRAD model for the groundwater protection model are limited to use for screening purposes only.

C3.3.2 Human Exposure Assumptions

The estimation of exposure requires numerous assumptions to describe potential exposure scenarios. Upper-bound exposure assumptions are used to estimate "reasonable maximum" exposure conditions to provide a bounding estimate on exposure. The exposure assumptions and methodology used to develop soil risk-based standards for nonradiological constituents. The assumptions and methodology used to calculate risk and dose estimates for radiological constituents are described in the following subsections.

C3.3.2.1 Nonradiological Constituents

Exposure assumptions and methodology used for developing the direct-contact risk-based standards under the industrial land-use scenario are provided in WAC 173-340-745.

As discussed in the CSM, groundwater at the waste sites is not used for drinking water purposes. However, exposure assumptions are provided for the groundwater ingestion pathway for the purpose of evaluating the groundwater protection pathway. The exposure assumptions and methodology used for deriving soil concentrations for groundwater protection are provide in WAC 173-340-747, "Model Toxics Control Act – Cleanup," "Deriving Soil Concentrations for Ground Water Protection."

Exposure estimates for current and future industrial workers are based on the assumption that a 70 kg adult would contact surface soil 146 days/yr over 20 years. For the direct-contact pathway, an incidental soil ingestion rate of 50 mg/day was assumed. For the inhalation pathway, an inhalation rate of 20 m^3/day was assumed. For the groundwater protection pathway, a drinking water ingestion rate of 2 L/day was assumed.

C3.3.2.2 Radiological Constituents

Exposure assumptions and methodology used for developing risk and dose estimates for the industrial and hypothetical Native American subsistence scenarios were obtained from DOE/RL-91-45, *Hanford Site Risk Assessment Methodology*; Harris and Harper (1997); and ANL 2002. The scenarios evaluated were selected based on the conceptual exposure model (Figure C-1) and are consistent with the reasonably anticipated future land uses.

The RESRAD model allows the use of site-specific chemical and physical parameters to estimate risk and dose. Site-specific parameters include depth of contamination, depth of clean cover, soil density, volumetric moisture, and chemical-specific distribution coefficients (K_ds). A detailed list of the site-specific input parameters is provided in the RI.

An analysis of the K_ds was conducted based on several studies that have been prepared for the 200 Areas. The K_d values that were selected for use in the RESRAD modeling are provided in PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Areas Plateau of the Hanford Site*. The "Zone F" category values were used because this category represents the type of waste that was disposed of in the 200-TW-1 and 200-PW-5 analogous waste sites. The Zone F category is defined as sources with low organics, low salts, and near-neutral conditions. These K_ds were within the range from the documents reviewed.

Industrial Land-Use Scenario. Exposure estimates for the current and future industrial worker are based on the assumption that a 70 kg adult would be exposed to surface soil 2,000 hours/yr (14% of the year spent indoors and 9% of the year spent outdoors) over 30 years. An incidental soil ingestion rate of 100 mg/day and an inhalation rate of 20 m^3/day were assumed. For the groundwater protection pathway, a drinking water ingestion rate of 2 L/day was assumed.

Hypothetical Native American Subsistence Scenario. Exposure assumptions for the Native American subsistence scenario were obtained from Harris and Harper (1997). This study suggests that a traditional Tribal member would lead a moderately active lifestyle, spending 180 days/yr conducting various subsistence activities (e.g., hunting, fishing, and gathering) and spending the full year consuming materials obtained through these activities. In addition, as much as 3.6 hours/day could be spent swimming or performing other water-contact activities. This lifestyle would be applied over a 70-year lifetime.

This exposure scenario assumes that radiological contaminants from each waste site do not reach the Columbia River and fish are not affected by past waste site activities. Therefore, the contaminants from 200-TW-1 and 200-PW-5 OU analogous waste sites currently present in the vadose zone are not expected to have any effect on the Columbia River. Based on this information, contaminants from these waste sites are not expected to contaminate the fish in the river by contaminating the water.[6]

C3.3.3 Equations for Soil Risk-Based Standards

For the majority of nonradiological constituents detected, soil risk-based standards were obtained from Ecology 94-145, *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC) Version 3.1*. Soil risk-based standards were not available for titanium; therefore, a soil risk-based standard was calculated for this constituent. The following

[6] The fish ingestion pathway in the RESRAD model is turned off.

subsections provide the equations used to calculate the soil risk-based concentrations under the industrial land-use exposure scenarios for carcinogens and noncarcinogens.

Carcinogens. The following equation was used to calculate the WAC 173-340-745, Method C soil risk-based standards for carcinogenic chemicals:

$$Soil\ Concentration(mg/kg) = \frac{TR \times BWc \times ATC \times UCF}{CPF_o \times SIR \times ABS_{gi} \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the WAC 173-340-745, Method C soil risk-based standards for noncarcinogenic chemicals:

$$Soil\ Concentration(mg/kg) = \frac{THQ \times BW_{nc} \times ATN \times UCF \times RfD_o}{EF \times ED \times SIR \times ABS_{gi}}.$$

C3.3.4 Equations for Ambient Air Cleanup Levels

Ambient air risk-based standards were calculated for all COPCs identified in Section C3.2.2. The following subsections provide the equations used to calculate the ambient air risk-based concentrations under the industrial land-use exposure scenario for carcinogens and noncarcinogens.

Carcinogens. The following equation was used to calculate the WAC 173-340-750 "Model Toxics Control Act – Cleanup," "Cleanup Standards to Protect Air Quality," Method C ambient air risk-based standards for carcinogenic chemicals:

$$Air\ Concentration(mg/m^3) = \frac{TR \times BWc \times ATC}{CPF_i \times INH \times ABS_{INH} \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the WAC 173-340-750, Method C ambient air risk-based standards for noncarcinogenic chemicals:

$$Air\ Concentration(mg/m^3) = \frac{THQ \times BW_{nc} \times ATN \times RfDi}{EF \times ED \times INH \times ABS_{inh}}.$$

C3.3.5 Equations for Groundwater Risk-Based Standards

For the majority of nonradiological constituents detected, groundwater risk-based standards were obtained from the CLARC tables (Ecology 94-145). Groundwater risk-based standards were not available for benzoic acid, cobalt, hexane, and titanium; therefore, groundwater risk-based standards were calculated for these constituents. The following subsections provide the equations used to calculate the groundwater risk-based concentrations under the unrestricted land-use exposure scenario for carcinogens and noncarcinogens.

Carcinogens. The following equation was used to calculate the WAC 173-340-747, Method B groundwater risk-based standards for carcinogenic chemicals:

$$Groundwater\ Concentration(ug/L) = \frac{TR \times BWc \times ATC \times UCF}{CPF \times DWIR \times INH \times DWF \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the WAC 173-340-747, Method B groundwater risk-based standards for noncarcinogenic chemicals:

$$Groundwater\ Concentration(ug/L) = \frac{THQ \times BW_{nc} \times ATN \times UCF \times RfD_o}{DWF \times ED \times DWIR \times INH}.$$

C3.3.6 Equations for Soil Concentrations Protective of Groundwater

The following subsections provide the equations used to calculate the soil concentrations that will not cause concentrations in groundwater to exceed the groundwater risk-based standards established under WAC 173-340-720, "Model Toxics Control Act – Cleanup," "Ground Water Cleanup Standards." The groundwater concentration (C_w) used in the equation was equal to the groundwater risk-based standard unless a Federal drinking water maximum contaminant level (MCL) was available. When an MCL was available for a constituent, the lower of the MCL or the groundwater risk-based standard was selected as the groundwater concentration. The three-phase partitioning equation was used to derive soil concentrations protective of groundwater:

$$Cs = C_w \times UCF \times DF \times \left[K_d + \frac{\theta_w + \theta_a \times H'}{\rho_b} \right]$$

where

C_s = calculated soil concentration (mg/kg)
C_w = groundwater risk-based standard established under WAC 173-340-720 (µg/L)
UCF = unit conversion factor (1×10^{-3} mg/µg)
DF = dilution factor (20 unitless)
K_d = distribution coefficient (chemical-specific) (L/kg)
Θ_w = water-filled soil porosity (0.3 mL/mL)
Θ_a = air-filled soil porosity (0.13 mL/mL)
H'= Henry's Law constant (chemical-specific) (dimensionless)
P_b = dry soil bulk density (1.5 kg/L).

When a published K_d was not available, the following equation was used to calculate the distribution coefficient:

$$K_d = K_{oc} \times f_{oc}$$

where:

K_d = distribution coefficient (chemical-specific) (L/kg)
K_{oc} = soil organic carbon-water partitioning coefficient (chemical-specific) (mL/g)
F_{oc} = soil fraction of organic carbon (0.001 g/g).

C3.3.7 Sources of Toxicity Values

Toxicity values used to calculate the soil and groundwater risk-based standards were obtained from the following sources:

- The primary source of toxicity values (i.e., cancer potency factors and oral reference doses) is the EPA's Integrated Risk Information System (IRIS) database, available on the Internet at http://www.epa.gov/iris/index.html.
- If a toxicity value was not available from IRIS, toxicity values published in EPA/540/R-97/036, *Health Effects Assessment Summary Tables, FY 1997 Update*, were used or the EPA's *Region 9 [Preliminary Remediation Goals] PRGs 2002 Tables* (EPA 2002) were used.

C3.4 RISK ASSESSMENT RESULTS FOR NONRADIOLOGICAL CONSTITUENTS

All nonradiological COPCs identified in Section C3.2.2 were compared to WAC 173-340-745, Method C risk-based standards developed for the direct-contact pathway. Additionally, nonradiological constituents were compared to the WAC 173-340-747, Method B soil concentrations protective of groundwater.

All risk-based standards developed for these waste sites were based on chronic or carcinogenic threats. Each true mean soil concentration was compared to its respective risk-based standard. WAC 173-340-745 states that carcinogenic risks should be less than 1×10^{-5} for Method C. Concentrations of individual noncarcinogenic constituents that pose a chronic toxic effect to human health should not exceed a hazard quotient (HQ) of 1.0.

The HQ can be back-calculated by dividing the concentration term by its respective noncancer risk-based standard. As described in the previous paragraph, a ratio greater than one suggests a potential for adverse health effects as defined by WAC 173-340-745(5)(B).

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For a given chemical and route of exposure, excess lifetime cancer risk (ELCR) can be back-calculated by dividing the concentration term by its cancer risk-based standard and multiplying by 10^{-5} (for industrial exposure) to estimate the chemical-specific risk. An ELCR that exceeds the target risk threshold of 1×10^{-5} indicates that, as a plausible upper bound, an individual has a one-in-one-hundred-thousand chance of developing cancer as a result of site-related exposure to a carcinogen over a 75-year lifetime under the specific exposure conditions at that waste site.

The EPA generally considers action to be warranted at a waste site when cancer risks exceed 1×10^{-4} based on a reasonable maximum exposure (RME) scenario. Action generally is not required for risks falling within 1×10^{-4} to 1×10^{-6}; however, this is judged on a case-by-case basis. Risks of less than 1×10^{-6} generally are not of concern to regulatory agencies. A hazard index (the ratio of chemical intake to the reference dose greater than one indicates that some potential exists for adverse noncancer health effects associated with exposure to the contaminants of concern (OSWER Directive 9285.6-03).

C3.4.1 Comparison Results to WAC 173-340-745, Method C Direct-Contact and WAC 173-340-747, Method B Groundwater Protection Cleanup Levels

All representative and analogous waste sites evaluated for the 200-TW-1, 200-TW-2, and 200-PW-5 OUs are located within the core zone and were compared to the industrial land-use direct-contact (WAC 173-340-745, Method C) and WAC 173-340-747, Method B groundwater protection risk-based standards. Comparison results for each representative waste site are provided in the RI and, for the 216-B-58 Trench in Section 2.0 of this FS. Comparison results for each analogous waste site are provided in Tables C-31 through C-37 for the shallow zone and in Tables C-38 through C-44 and C-71 for the deep zone.

C3.4.1.1 216-B-43 Crib

Direct Contact. As shown in Table C-31, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-38 (except for the nitrogen in nitrite and nitrate, total uranium, and pentachlorophenol), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based concentrations. The true mean concentration for nitrogen in nitrate (421 mg/kg) exceeds the risk-based standard of 40 mg/kg; the true mean concentration for nitrogen in nitrite (40 mg/kg) exceeds the risk-based standard of 4.0 mg/kg; the true mean concentration for total uranium (5.2 mg/kg) exceeds the risk-based standard of 1.3 mg/kg; and the true mean concentration of pentachlorophenol (0.70 mg/kg) exceeds the risk-based standard of 0.012 mg/kg. Pentachlorophenol only was detected two times at detection limit levels. This is not considered a significant threat to the groundwater.

C3.4.1.2 216-B-44 Crib

Direct Contact. As shown in Table C-32, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-39 (with the exception of nitrogen in nitrite and nitrate, and uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for nitrogen in nitrite and nitrate (561 mg/kg) slightly exceeds the risk-based standard of 40 mg/kg, and the true mean concentration for uranium (25 mg/kg) exceeds the WAC 173-340-747 risk-based standard of 1.3 mg/kg.

C3.4.1.3 216-B-45 Crib

Direct Contact. As shown in Table C-33, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-40 (except for aluminum, cadmium, nitrogen as nitrate and nitrite, and uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for aluminum (7,479 mg/kg), cadmium (0.90 mg/kg), nitrogen as nitrate (244 mg/kg), and uranium (13 mg/kg) exceed their respective WAC 173-340-747 risk-based standards of 45 mg/kg, 0.69 mg/kg, 40 mg/kg, and 1.3 mg/kg, respectively. However, the true mean cadmium concentration does not exceed the background value of 1.0 mg/kg, which is the default standard because background exceeds the WAC 173-340-747 risk-based standard.

C3.4.1.4 216-B-47 Crib

Direct Contact. As shown in Table C-34, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-41 (except for pentachlorophenol and uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for pentachlorophenol (0.73 mg/kg) and uranium (61 mg/kg) exceed their respective risk-based standards of 0.012 mg/kg and 1.3 mg/kg, respectively. Pentachlorophenol was only detected two times at detection limit levels. This is not considered a significant threat to the groundwater.

C3.4.1.5 216-B-48 Crib

Direct Contact. As shown in Table C-35, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-42 (except for nitrogen as nitrate and nitrite and uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for nitrogen as nitrate (276 mg/kg) and uranium (1,631 mg/kg) exceed their respective WAC 173-340-747 risk-based standard of 40 mg/kg, 50 mg/kg, and 1.3 mg/kg, respectively.

C3.4.1.6 216-B-49 Crib

Direct Contact. As shown in Table C-36, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-43 (except for uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for uranium (10 mg/kg) exceeds the risk-based standard of 1.3 mg/kg.

C3.4.1.7 216-B-50 Crib

Direct Contact. As shown in Table C-37, the true mean concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-44 (except for uranium), the true mean concentrations for all constituents are less than their respective WAC 173-340-747 risk-based standards. The true mean concentration for uranium (10 mg/kg) exceeds the risk-based standard of 1.3 mg/kg.

C3.4.1.8 216-B-26 Trench

Direct Contact. As shown in Table C-70, the maximum detected concentrations for all constituents are less than their respective WAC 173-340-745 risk-based standards.

Groundwater Protection. As shown in Table C-71, the maximum detected concentration for manganese, uranium, and nitrate exceed the risk-based standards.

C3.4.2 Results of Comparison to Air Cleanup Levels

All shallow zone soil sample results from each representative waste site were pooled and the maximum detected concentration of each COPC identified was compared to WAC 173-340-750, Method C ambient air risk-based standard. The maximum air concentrations were calculated using the methodology presented in Section C2.4.5. Average concentrations are compared to WAC 173-340-750, Method C ambient air risk-based standards in Table C-45. As shown, the maximum air concentrations for all constituents are less than their respective ambient air risk-based standards.

C3.5 RISK ASSESSMENT RESULTS FOR RADIOLOGICAL CONSTITUENTS

All radiological COPCs identified in Section C2.4.5 were evaluated under the industrial, hypothetical Native American subsistence, and groundwater protection exposure scenarios. Each direct-contact exposure scenario was evaluated with and without cover material.[7] All scenarios were evaluated with the absence of clean cover, assuming a contaminated zone ranging from 0 m to 4.6 m (0 to 15 ft) (contaminant concentrations provided in Tables C-2 through C-8 for shallow zone soil and in Tables C-9 through C-15 for deep zone soil). Exposure times were carried out to 1,000 years for each analogous waste site evaluated.

The following RA results focus on the industrial exposure scenario. The hypothetical Native American subsistence exposure scenario was evaluated to provide a basis of comparison (assuming unrestricted land use) to the industrial exposure scenario.

For the purposes of this RA, the radiation dose limit for each of the exposure scenarios evaluated (industrial and hypothetical Native American) is 15 mrem/yr (10 CFR 835, "Occupational Radiation Protection"). This dose limit is developed for members of the public who are unknowingly exposed to radiation and is approximately equivalent to an ELCR of 1×10^{-4}.

C3.5.1 Summary of Dose and Risk Estimates for Radiological Constituents

Tables C-46 through C-48 present the input parameters used for the RESRAD modeling for the industrial, Native American, and groundwater protection scenarios. Tables C-49 through C-52 and Tables C-53 and C-54 summarize the dose and risk estimates for each of the analogous waste sites for direct contact and for the groundwater protection pathway, respectively.

For comparison, risk and dose estimates are discussed relative to the following exposure times, which are based on the results of risk framework workshops as documented in the Ecology, EPA, and DOE response to the Hanford Advisory Board (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"), as amended.

- 50 years is the estimated time that DOE will have an onsite presence.
- 150 years is the estimated time that institution controls are assumed to be effective.
- Dose estimates are provided for the exposure time when the target dose limit of 15 mrem/yr is achieved.

C3.5.1.1 216-B-43 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-2, the maximum total dose rate at the 216-B-43 Crib is 3.85 mrem/yr at year 0. As shown in Table C-50 and Figure C-3, the maximum ELCR is 7.7×10^{-5} at year 0. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is within or less than the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-4, the maximum total dose rate at the 216-B-43 Crib to the hypothetical Native American receptor is 59 mrem/yr at year 0. As shown in Table C-52 and Figure C-5, the maximum ELCR is 9.8×10^{-4}. The ELCR under this exposure scenario is never less than the target risk range of 1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are cesium-137 and strontium-90.

Groundwater Protection. As shown in Table C-53 and Figure C-6, the maximum total dose rate at the 216-B-43 Crib is 0.68 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-6, the ELCR is 2.1×10^{-4} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.2 216-B-44 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-7, the maximum total dose rate at the 216-B-44 Crib is 4.58 mrem/yr at year 0. As shown in Table C-50 and Figure C-8, the maximum ELCR is 9.0×10^{-5} at years 0 and 1. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-9, the maximum total dose rate at the 216-B-44 Crib to the hypothetical Native American receptor is 53 mrem/yr at year 0. As shown in Table C-52 and Figure C-10, the maximum ELCR is 9×10^{-4}. The ELCR under this exposure scenario is never less than the target risk range of 1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are cesium-137, radium-226, and strontium-90.

Groundwater Protection. As shown in Table C-53 and Figure C-11, the maximum total dose rate at the 216-B-44 Crib is 0.65 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-11, the ELCR is 2×10^{-4} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.3 216-B-45 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-12, the maximum total dose rate at the 216-B-45 Crib is 3.11 mrem/yr at year 0. As shown in Table C-50 and Figure C-13, the maximum ELCR is 6.1×10^{-5} at year 0. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-14, the maximum total dose rate at the 216-B-45 Crib to the hypothetical Native American receptor is 35 mrem/yr at year 0. As shown in Table C-52 and Figure C-15, the maximum ELCR is 6.3×10^{-4}. The ELCR under this exposure scenario is never less than the target risk range of 1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are cesium-137, radium-226, and strontium-90.

Groundwater Protection. As shown in Table C-53 and Figure C-16, the maximum total dose rate at the 216-B-45 Crib is 0.33 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-16, the ELCR is 1×10^{-4} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.4 216-B-47 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-17, the maximum total dose rate at the 216-B-47 Crib is 51.2 mrem/yr at year 0. As shown in Table C-50 and Figure C-18, the maximum ELCR is 9.6×10^{-4} at year 0. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is never within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4}. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-19, the maximum total dose rate at the 216-B-47 Crib to the hypothetical Native American receptor is 46 mrem/yr at year 0. As shown in Table C-52 and Figure C-20, the maximum ELCR is 8×10^{-3}. The ELCR under this exposure scenario is never less than the target risk range of 1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are cesium-137, radium-226, and strontium-90.

Groundwater Protection. As shown in Table C 53 and Figure C-21, the maximum total dose rate at the 216-B-47 Crib is 0.09 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-21, the ELCR is 2.8×10^{-5} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.5 216-B-48 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-22, the maximum total dose rate at the 216-B-48 Crib is 4.68 mrem/yr at year 0. As shown in Table C-50 and Figure C-23. the maximum ELCR is 9.5×10^{-5} at year 0. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-24, the maximum total dose rate at the 216-B-48 Crib to the hypothetical Native American receptor is 133 mrem/yr at year 0. The total dose exceeds 15 millirem per year for the entire period evaluated (1,000 years). As shown in Table C-52 and Figure C-25, the maximum ELCR is 2×10^{-3}. The ELCR under this exposure scenario is never less than the target risk range of

1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are radium-226 and strontium-90.

Groundwater Protection. As shown in Table C-53 and Figure C-26, the maximum total dose rate at the 216-B-48 Crib is 0.65 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-26, the ELCR is 2×10^{-4} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.6 216-B-49 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-27, the maximum total dose rate at the 216-B-49 Crib is 0.921 mrem/yr at year 0. As shown in Table C-50 and Figure C-28, the maximum ELCR is 1.5×10^{-5} at year 0. The ELCR under this exposure scenario is less than the target risk level of 1.0×10^{-5} for years 50 through 1,000. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributor to total dose and risk is cesium-137.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-29, the maximum total dose rate at the 216-B-49 Crib to the hypothetical Native American receptor is 76 mrem/yr at year 0. As shown in Table C-52 and Figure C-30, the maximum ELCR is 1×10^{-3}. The ELCR under this exposure scenario is less than the lower target risk of 1×10^{-6} after 500 years The primary contributors to total dose and risk are cesium-137 and strontium-90.

Groundwater Protection. As shown in Table C-53 and Figure C-31, the maximum total dose rate at the 216-B-49 Crib is 0.3 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-31, the ELCR is 9.2×10^{-5} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.7 216-B-50 Crib

Industrial Scenario. As shown in Table C-49 and Figure C-32, the maximum total dose rate at the 216-B-50 Crib is 4.37 mrem/yr at year 0. As shown in Table C-50 and Figure C-33, the maximum ELCR is 8.5×10^{-5} at year 0. The ELCR under this exposure scenario is never less than the target risk level of 1.0×10^{-5}. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributors to total dose and risk are cesium-137 and radium-226.

Hypothetical Native American Scenario. As shown in Table C-51 and Figure C-34, the maximum total dose rate at the 216-B-50 Crib to the hypothetical Native American receptor is 38 mrem/yr at year 0. As shown in Table C-52 and Figure C-35, the maximum ELCR is 7.2×10^{-4}. The ELCR under this exposure scenario is never less than the target risk range of 1.0×10^{-4} to 1×10^{-6}. The primary contributors to total dose and risk are cesium-137 and radium-226.

Groundwater Protection. As shown in Table C-53 and Figure C-36, the maximum total dose rate at the 216-B-50 Crib is 0.49 mrem/yr at year 50. Based on the RESRAD screening, the dose rate is never above the target dose rate of 4 mrem/yr. As shown in Table C-54 and Figure C-36, the ELCR is 1.3×10^{-4} at year 50. The ELCR is below 1.0×10^{-6} for all times after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.5.1.8 216-B-26 Trench

Industrial Scenario. As shown in Table C-49, the maximum total dose rate at the 216-B-26 Trench is 3.1×10^{-5} mrem/yr at year 0. As shown in Table C-50, the maximum ELCR is 4.3 mrem/yr at year 0. The ELCR under this exposure scenario is within the target risk range of 1.0×10^{-4} to 1.0×10^{-6} only at year 500. The primary contributors to total dose and risk are cesium-137 and plutonium-239.

Groundwater Protection. As shown in Table C-53, the maximum total dose rate at the 216-B-26 Trench is 360 mrem/yr at year 68. As shown in Table C-54, the ELCR is 1.1×10^{-3} at year 68. The ELCR is below 1.0×10^{-6} for all time after 150 years. The primary contributor to total dose and risk is technetium-99.

C3.6 UNCERTAINTY ANALYSIS

Several sources of uncertainty affect the overall estimates of ELCR and noncarcinogenic hazards as presented in this HHRA.

C3.6.1 Uncertainty Associated with Sampling and Analysis

Uncertainties associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the quality assurance/quality control program used in conducting the sampling and analysis reduces errors, it cannot eliminate all errors associated with sampling and analysis.

C3.6.2 Uncertainty Associated with Exposure Assessment

Future soil EPCs were assumed to be equal to existing soil concentrations. This assumption does not account for fate and transport processes likely to occur in the future; risk estimates are likely to be overestimated for future exposure scenarios.

The estimation of exposure requires many assumptions to describe potential exposure situations. Uncertainties exist regarding the likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. These tend to simplify and approximate actual waste site conditions. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

The WAC 173-340 default exposure assumptions were conservatively used to estimate the current and future industrial land-use scenario. It is unlikely that an industrial worker would work solely at one waste site over a 25-year exposure period. Similarly, it is unlikely that a Native American would reside at any one of the waste sites evaluated over an entire lifetime. The default exposure assumptions for the industrial and hypothetical Native American subsistence land-use scenarios likely overestimate dose and risk at the site.

C3.6.3 Uncertainty Associated with Toxicity Assessment

The toxicological database also was a source of uncertainty. The EPA has outlined some of the sources of uncertainty in the RA guidance for the Superfund (EPA/540/1-89/002). These sources may include or result from the extrapolation from high to low doses and from animals to humans; the species, gender, age, and strain differences in a toxin's uptake, metabolism, organ distribution, and target site susceptibility; and the human population's variability with respect to diet, environment, activity patterns, and cultural factors.

Toxicity values were not available for yttrium, zirconium, 2,3,7-trimethyloctane, 2,6-di-tert-butyl-p-benzoquinone, 2-(2-ethoxyethoxy)ethanol, 2-methylnaphthalene, 4-chloro-3-methylphenol, acenaphthylene, atomic sulfur, benzo(ghi)perylene, decamethylcyclopenta-siloxane, diacetone alcohol, dodecane, 2,7,10-trimethyl-dodecane, eicosane, 2,6,10,15-tetramethyl-heptadecane, hexadecane, pentadecane, tetradecane, tributyl phosphate, tridecane, undecane, kerosene, hexanal, and general chemical parameters, including chloride, fluoride, phosphate, sulfate, and total organic carbon. Therefore, these constituents were not evaluated in the RA. Excluding these constituents potentially could underestimate risk at the site.

C3.6.4 Uncertainty Associated with Risk Characterization

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancerous adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, did not account for the possibility that constituents act synergistically or antagonistically.

C4.0 ECOLOGICAL RISK ASSESSMENT

This section provides the methodology and results of the SLERA for the 200-TW-1 and 200-PW-5 analogous waste sites. The SLERA assesses the potential impacts of past releases to soil on wildlife using the waste sites, assuming the absence of remediation. The objectives of this SLERA are (1) to evaluate the potential for ecological exposures from these releases and (2) to identify the likelihood of adverse impacts on wildlife populations that might use the investigation area. The outcome of this SLERA will be used to determine the environmental measurements necessary to support the RI/FS process and remedial decision making for these OUs.

C4.1 INVESTIGATION AREAS

As described in the CSM (Section C.2.4.4), all of the eight analogous waste sites evaluated contain habitat that wildlife could use.

C4.2 ECOLOGICAL RISK ASSESSMENT GUIDANCE

The EPA, Ecology, and DOE have published guidance documents for performing ERAs. The procedures used for this ERA are consistent with those described in the following documents:

- EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*
- EPA-540-R-97-006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*

- EPA 910-R-97-005, *EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund*
- EPA/630/R-92/001, *Framework for Ecological Risk Assessment*
- DOE/STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (developed by the Biota Dose Assessment Committee ([BDAC])
- DOE/RL-91-45, *Hanford Site Risk Assessment Methodology*
- DOE/RL-2001-54, *Central Plateau Ecological Evaluation.*

C4.3 OVERVIEW OF THE ECOLOGICAL RISK ASSESSMENT APPROACH

The general approaches for conducting an ERA in accordance with EPA, Ecology, and DOE guidance are presented in DOE/RL-2001-54. The following subsections summarize the site-specific framework for the 200-TW-1 and 200-PW-5 analogous waste sites with data.

C4.3.1 Nonradionuclides

This ERA is structured in a way that is consistent with both EPA (EPA/540/R-97/006, EPA/910/R-97/005, and EPA/630/R-95/002Fa) and Ecology ERA guidance documents. This ERA, which uses conservative screening values provided by Ecology (WAC-173-340-900), corresponds to Steps 1 (preliminary problem formulation) and 2 (screening) of the EPA guidance EPA/540/R-97/006). The SLERA (Step 2) intentionally is conservative and serves to eliminate from further evaluation analytes and waste sites that obviously do not pose a risk to the environment despite the SLERA's bias toward overestimating risk. The SLERA is used to determine whether further evaluation (i.e., baseline ecological RA) or remedial actions may be necessary.

C4.3.2 Radionuclides

The EPA and Ecology guidance documents do not address radionuclides; therefore, the potential effects of surface residual contamination on terrestrial receptors were evaluated using the terrestrial radionuclide screening levels presented in DOE-STD-1153-2002, developed by the DOE and BDAC. The BDAC has been assisting DOE in developing a technical standard that provides a graded approach for evaluating radiation doses to biota. The technical standard has been approved by DOE for assessing the ecological effects of radiological exposure when conducting ERAs.

DOE's graded approach for evaluating radiation doses to biota consists of a three-step process designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information (if needed) and is consistent with the eight-step EPA approach for conducting ERAs. DOE recommends the following three-step process:

1. Assembling radionuclide concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated.
2. Applying a general screening methodology that provides limiting radionuclide concentration values (i.e., the biota concentration guide [BCG], proposed by the BDAC in DOE-STD-1153-2002) in soil.

3. If needed, conducting risk evaluation through site-specific screening, site-specific analysis, or an actual site-specific biota dose assessment within an ecological risk framework, similar to that recommended in EPA/630/R-95/002F.

Any of the steps in the graded approach may be used at any time. To avoid confusion with the eight-step EPA process, the DOE's steps for evaluating risks posed by radionuclides are referred to as Levels 1 through 3 throughout the remainder of this document. These levels roughly coincide with Step 2 of EPA's process. This SLERA uses Level 1, part of Level 2 (e.g., mean concentrations), and a simplified Level 3 to assess the risks to wildlife potentially exposed to radionuclides at the 200-TW-1 and 200-PW-5 analogous waste sites.

The BCGs contained in the technical standard guidance include conservative screening concentrations that are judged to be protective of the most sensitive terrestrial organisms tested (e.g., small mammals), assuming a dose threshold of 0.1 rad/day. The BCGs were developed from dose-response relationships for chronic reproductive effects (Jones et al. 2003, "Principles and Issues in Radiological Ecological Risk Assessment"). Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not exceed DOE's established or recommended dose standards for biota protection. Therefore, surface soil concentrations of less than the BCGs are not considered to pose a threat to terrestrial receptors.

C4.4 ORGANIZATION OF THE ECOLOGICAL RISK ASSESSMENT

The remainder of this assessment has been organized into the following subjects to identify the potential for ecological risk at the 200-TW-1 and 200-PW-5 analogous waste sites.

- **SLERA:** Presents the methodologies and results of the SLERA (Section C4.5).
- **Characterization of uncertainty:** Identifies uncertainties in the assumptions used to estimate risk to ecological endpoint species (Section C4.6).
- **Evaluation of ecological significance:** Discusses the significance of the results of the SLERA; collectively considers the results of the SLERA in light of the assumptions and inherent limitations of the analyses (Section C4.7).
- **Conclusions/recommendations:** Summarizes the conclusions and recommendations based on the results of the SLERA (Section C4.8).

C4.5 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

This ERA is consistent with the eight-step ERA process developed for the Superfund program in EPA-540-R-97-006. The process starts with a SLERA, which is considered to follow Steps 1 and 2 of the EPA ERA guidance (EPA/630/R-95/002F). The primary purposes of Steps 1 and 2 are to quickly and efficiently identify analytes and sites with minimal potential for ecological risk, and to eliminate them from further evaluation. The first step, preliminary problem formulation, is considered a conservative, qualitative determination of whether ecological receptors, habitat, and exposure pathways are present at a site. The information provided in Sections C2.1, C2.2, and C2.4 of this appendix satisfy Step 1 and indicate that a potential for complete ecological exposure pathways exists at the five 200-TW-1 and 200-TW-2 Area waste sites being evaluated in the SLERA. Step 2, ecological risk-based screening, is a conservative assessment of whether constituents detected at the 200-TW-1 and 200-PW-5 analogous waste sites are present at concentrations that are sufficiently high to indicate a potential for risk at the waste sites and to support a decision to proceed to a baseline ERA (Steps 3 through 7 of the eight-step ERA process) or discuss remedial alternatives. Therefore, results of a SLERA are used to determine which of the following recommendations can be made:

- No further ecological investigations at the waste site
- Continuation of the RA process at the next level (baseline ERA)
- Take a removal or remedial action to address potential risks.

C4.5.1 Screening-Level Ecological Risk Assessment Methodology

The SLERA process used is as described in DOE/RL-2001-54. For nonradionuclides, the SLERA is consistent with EPA's ERA guidance (EPA/540/R-97/006 and EPA/630/R-95/002F) and the process outlined in WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." The methodology for the radionuclide ecological evaluation follows the process developed by the BDAC in DOE-STD-1153-2002. During the SLERA, site media concentrations are compared to conservative risk-based media concentrations that are anticipated to be without ecological consequences. These risk-based media concentrations were obtained from both Ecology (for nonradionuclides) and DOE (for radionuclides) sources.

C4.5.1.1 Nonradionuclides

Under WAC 173-340, a distinction is made between commercial/industrial and all other types of land use. For a commercial or industrial property, only potential exposure pathways to wildlife need to be considered (i.e., soil biota and plants are not intended to be protected because of the site land use), while plants and soil biota must be considered along with wildlife at sites designated for other land uses. According to WAC 173-340-200, "Definitions," "industrial properties" are those that are or have been characterized by or are to be committed to traditional industrial uses such as processing or manufacturing of materials; marine terminal and transportation areas and facilities; fabrication, assembly, treatment, or distribution of manufactured products; or storage of bulk materials, that are zoned for industrial use by a city or county. The 200-TW-1 and 200-PW-5 analogous waste sites are in an area considered to be industrial property, which will remain unchanged in the future because of land-use restrictions. Therefore, each area was screened only against the wildlife screening values provided in WAC 173-340-900, Table 749-3. These values represent conservative "no observed adverse effect level" (NOAEL)-based screening levels that are protective of wildlife populations and include protection for potential chemical exposure through the food chain. Surface soil concentrations 0 to 3 m (0 to 15 ft bgs) are compared with these wildlife screening values.

C4.5.1.2 Radionuclides

The WAC 173-340-7490 regulations and the screening values presented in WAC 173-340-900, Table 749-3, address only nonradionuclide chemicals. Because radionuclide chemicals are present at the Hanford Site, the BCG screening values provided in the DOE-STD-1153-2002 have been used to screen radionuclides. The default terrestrial wildlife BCGs are soil concentrations that have been calculated for a hypothetical small mammal and use high-end exposure assumptions that include, but are not limited to, the following: small body weight, high ingestion rate compared to body weight, continuous exposure to radiation from all directions, 100% area use, and high incidental soil ingestion rates. The model also assumes that a dose of 0.1 rad/day is protective of ecological populations. This dose is based on preventing effects to the most sensitive species tested. Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media that would not exceed DOE's recommended dose standards for biota. These BCG values represent conservative NOAEL-based screening levels assumed to be protective of wildlife populations and include protection for potential radionuclide exposures through the food chain. In addition, because the effects of exposure to multiple radionuclides can be additive, all radionuclide fractions (maximum concentration/BCG) have been summed as follows:

$$\text{Total risk estimate} = \sum (\text{maximum radionuclide concentration/BCG}).$$

If the total risk estimate (sum of all fractions) is less than 1.0, the ecological risk is considered acceptable and the evaluation for radionuclides is complete. The guidance uses three levels to evaluate the potential risk to ecological receptors, with the first level being the most conservative. Level 1 uses maximum detected concentrations rather than the 95% UCL recommended by WAC 173-340 regulations for the initial screening. Level 2 uses a screening of the arithmetic mean concentrations against BCGs. Therefore, in accordance with DOE-STD-1153-2002, the maximum and mean radionuclide concentrations have been compared to their respective BCGs, and all fractions have been summed to determine if the sum is less than 1.0. The following lists outline the primary assumptions used for estimating a BCG at each level of the SLERA for radionuclides, in accordance with the DOE guidance:

<u>Level 1 Assumptions</u>

1. Source in soil is infinite (i.e., nondepleting) and terrestrial wildlife are exposed to uniform radionuclide doses.
2. Exposed species have infinitely small mass, which results in an overestimation of the external dose rate for finite-sized organisms.
3. Wildlife species are immersed 100% of the time in the waste site soils.
4. 10% of the total diet for the wildlife species is from incidental ingestion of soil.
5. Initial exposure parameters (e.g., bioaccumulation factors, ingestion rate, etc.) are specifically chosen to produce very conservative BCGs, and some of these factors may range over several orders of magnitude, depending on biotic and abiotic features at the sites (DOE-STD-1153-2002).
6. The 100% area use factor is applied (i.e., the wildlife species are expected to forage and reside exclusively at each waste site).
7. Effect limits are based on the protection of the most radiologically sensitive species tested.
8. Maximum detected surface soil concentration is used in the BCG comparisons.

<u>Level 2 Assumptions</u>

For this SLERA, Level 2 assumptions are the same as Level 1 assumptions, except that mean surface soil concentrations are used for the BCG comparisons rather than the maximum detected concentration (includes all except No. 8 above).

Level 3 Assumptions

All of the conservative assumptions are the same as the Level 1 assumptions, except the following changes are made to No. 4, part of No. 5, and No. 8:

4. Because the model is based on exposure to small mammals (e.g., mice), the highest incidental soil ingestion rates for any rodent (2.8%) reported in the *Wildlife Exposure Factors Handbook* (EPA 1993) are applied in place of the default value of 10%.
5. Less conservative bioaccumulation factors (i.e., high-end rather than upper bound) from empirical studies reported in the DOE technical standard are applied. Specifically, the 95^{th} percentile animal-to-soil bioaccumulation value (20 for cesium-137) from a kinetic/ allometric method was applied (DOE-STD-1153-2002; Higley et al. 2003, "A Probabilistic Approach to Obtaining Limiting Estimates of Radionuclide Concentration in Biota").
8. As in Level 2, mean surface soil concentrations are used for the BCG comparisons.

Threatened and endangered species are of high concern at the Hanford Site. As mentioned in Section C2.1.3, two federally protected species have been observed at the Hanford Site: the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*). As migratory birds, these species also are protected under the *Migratory Bird Treaty Act*. Both of these species depend on the habitats along the river corridor for food sources and are rarely seen in the Central Plateau. No plants, invertebrates, amphibians, reptiles, or mammals are listed by the Federal or Washington State threatened and endangered species programs. Considering this, exposure of any Federal- or state-listed wildlife species is not likely to occur in at these analogous sites or at any of the 200-TW-1, 200-TW-2, or 200-PW-5 waste sites.

C4.5.2 Analysis and Results

Data collection activities during the RI are discussed in Section 2.0. Samples were collected from boreholes and were analyzed for volatile and semi-volatile organic compounds, inorganics (metals), total petroleum hydrocarbon (TPHs), general chemistry, and radionuclides. Samples also were collected for physical properties analysis, and data were validated in accordance with the project's quality assurance plan. Soil samples were collected during the RI at depths ranging from 0 to 4.6 m (0 to 15 ft) bgs. All of the samples included in this RA by station identification, sample identification, depth interval, and date of collection are summarized in Table C-55. Consistent with EPA recommendations for a SLERA, all chemicals that are detected at least once in any of the shallow zone soil samples were evaluated in the SLERA. The analyses and results of the screening are presented separately in the following subsections for nonradionuclides and radionuclides.

C4.5.2.1 Nonradionuclides

For each analogous waste site evaluated, the lower of the 95% UCL and the maximum detected concentration for each nonradionuclide constituent was screened against the wildlife screening values presented in WAC 173-340-900, Table 749-3, to determine if any chemical concentrations exceeded their respective screening values. The results of this screening for each representative waste site are presented in Tables C-56 through C-62 and C-70. The results of the terrestrial wildlife screening for nonradionuclides at the waste sites were that none of the COPCs exceeded the screening value.

C4.5.2.2 Radionuclides

For each analogous waste site evaluated, the maximum (Level 1) and mean (Level 2) detected concentration of each radionuclide were screened against the BCGs proposed by the BDAC (DOE-STD-1153-2002). The results of this screening are also presented in Tables C-63 through C-69. The results of the terrestrial wildlife screening for radionuclides at the analogous waste sites with data (216-B-43, 216-B-44, 216-B-45, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs and the 216-B-26 Trench) were that none of the radionuclides exceeded the screening value, except for cesium-137 and strontium-90 in the 216B-26 Trench. The maximum detected concentrations for cesium-137 (529,000 pCi/g) and strontium-90 (974,000 pCi/g) exceeded the ecological screening value of 20.0 pCi/g, which applies to both radionuclides.

C4.6 CHARACTERIZATION OF UNCERTAINTY

Uncertainties are inherent in all aspects of an ERA. The nature and magnitude of uncertainties depend on the amount and quality of the data available, the degree of knowledge concerning site conditions, and the assumptions made to perform the ERA. Uncertainties in ERA methods can result in either understating or overstating the ecological risks. Risk estimates are subject to uncertainty from a variety of sources, including the following:

- Sampling, analysis, and data evaluation
- Fate and transport estimation
- Exposure estimation
- Toxicological data.

C4.6.1.1 Sampling, Analysis, and Data Evaluation

Uncertainty associated with sampling and analysis includes the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. The quality assurance/quality control program used in the investigation reduces these errors, but it cannot eliminate all errors associated with sampling and analysis. The degree to which sample collection and analyses reflect real soil concentrations partly determines the reliability of the risk estimates. Sample data used for the SLERA were generated from samples collected at known or suspected source areas, rather than randomly. Because exposure to wildlife is not likely to be limited solely to higher concentration areas, risk estimates for these areas may be conservatively high.

C4.6.1.2 Fate and Transport Estimation

This SLERA makes simplifying assumptions about the environmental fate and transport of contaminants of ecological concern; specifically, that no chemical loss or transformation occurred. This assessment also assumes that the chemical concentrations detected in surface soil remain constant during the assessed exposure duration. In cases where natural attenuation and degradation processes are high, the analytical data chosen to represent soil concentrations may overstate actual long-term exposure levels. For example, this SLERA does not account for the decay of radionuclides over time; therefore, future exposure and risk from radionuclides at these waste sites will decrease.

C4.6.1.3 Exposure Estimation

The estimation of exposure requires many assumptions to describe potential exposure situations. Uncertainties exist regarding the likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. The assumptions used tend to simplify and approximate actual site conditions and may overestimate or underestimate the actual risks. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

For nonradionuclides, the EPCs used in the exposure assessment were the lower of the 95% UCL of the mean constituent concentration or the maximum detected concentration. The EPC was intended to provide a high-end estimate of actual exposure at the site because the potential receptors are assumed to be exposed to the 95% UCL or maximum detected constituent concentration for the entire duration of exposure. As the data indicate, constituent concentrations in many samples were significantly less than the 95% UCL or maximum detected concentration. The EPCs were assumed to remain constant for the duration of exposure (i.e., the physical, chemical, or biological processes that could reduce chemical concentrations or changes in the bioavailability of soil constituents over time have not been factored into the estimate of the EPCs). Use of this conservative assumption may overestimate exposure to receptor species.

The EPCs used for radionuclides in the SLERA were the mean constituent concentration at each waste site. Because of the mobility of the potential terrestrial wildlife receptors, sampling at known or suspected contamination areas, and the lower quality foraging habitats at the representative waste sites relative to other nearby areas, the mean should be considered as a conservative exposure concentration for measuring population-level effects. Although the mean serves as a good indicator of the actual risks to terrestrial wildlife populations, individual organisms (particularly less mobile organisms) could be exposed to higher concentrations.

Many of the waste sites were originally constructed at depths of 3 m (10 ft) or more and have subsequently been backfilled with additional clean soil. The depth of the clean material on the waste sites varies, as identified in Table 2-6 in the FS; however, depths are generally greater than 3 m (10 ft) bgs. Data used in this SLERA were collected at soil locations to depths of 4.6 m (15 ft) bgs. Because most wildlife exposures occur in the upper 0.6 m (2 ft) of soil, the data used serve as a conservative estimate of exposure and may overstate the actual risks.

For this SLERA, an area use factor was not applied (i.e., wildlife receptors are assumed to reside and exclusively forage at each investigation area). Because the habitat quality at the waste sites at the waste sites and most wildlife species are highly mobile, wildlife are unlikely to use only the waste sites. Use of this conservative assumption likely overestimates exposure to most potential receptor species.

C4.6.1.4 Toxicological Data

Toxicological data for wildlife often are limited for many contaminants. Most wildlife toxicity information is generated by laboratory studies with selected test species. These studies frequently evaluate domestic animals under controlled laboratory conditions, with few tests involving native wildlife. Basic toxicity information can be extrapolated to native species in the wild, but consideration must be given to the species involved and specific site conditions. The standard screening levels used in this SLERA were not calculated for receptor species that could occur at the waste sites. Depending on whether wildlife species at the site are less or more sensitive to the contaminants of concern than the default species in Ecology and DOE guidance, the actual risk may be overestimated or underestimated. The BCGs in DOE-STD-1153-2002 are based on a 0.1 rad/day limit for terrestrial wildlife. This limit is based on the protection of populations of the most radiosensitive species tested (primarily reptiles and small mammals), which likely overestimates the risk to most terrestrial wildlife at the 200-TW-1 and 200-PW-5 analogous waste sites (although some species could be more sensitive to radionuclide exposure). Also, because some of the constituents detected at the waste sites did not have available screening levels on which to quantify risks, these constituents could not be evaluated. In general, most of the constituents that have no available toxicity data are considered less toxic, because most of the toxicological literature focuses on those constituents considered more toxic to ecological receptors.

C4.7 EVALUATION OF ECOLOGICAL SIGNIFICANCE

Step 1 (preliminary problem formulation) of the ERA process revealed that ecological receptors and sufficient habitat are present or potentially present at the 200-TW-1 and 200-PW-5 OU analogous waste sites that were evaluated. The results of Step 2 (ecological risk-based screening) are provided in Tables C-53 through C-59 and indicate that none of the screening values have been exceeded, except for cesium-137 at the 216-B-26 Trench. Because of the limited area of the trench, the industrial nature of the surrounding area and the fact that the contaminants are covered by clean soil, no significant ecological impact will occur.

C4.8 CONCLUSIONS/RECOMMENDATIONS

This SLERA assesses the potential impacts on terrestrial wildlife from past releases to soil at the 200-TW-1 and 200-PW-5 analogous waste sites with data and was conducted in accordance with EPA, Ecology, and DOE guidance. The resulting characterization of potential risk is expected to provide enough information that informed decisions can be made about these waste sites. The primary decision for which the results of the screening ecological RA provide input is whether to address any areas and site-related constituents at the waste site because of the potential threat to the environment. Therefore, the results of a SLERA are used to determine which of the following recommendations can be made:

- No further ecological investigations at the waste site
- Continuation of the RA process at the next level
- Undertake a removal or remedial action.

Based on the nature and extent of constituent concentrations observed during the waste site investigation, and considering ecosystem characteristics, the following conclusions are made:

- On the basis of considering the background concentrations for metals at the Hanford Site and the screening levels for nonradionuclides, soil concentrations for nonradionuclides are not considered high enough to pose unacceptable risk to terrestrial wildlife at any of the 200-TW-1 and 200-PW-5 analogous waste sites evaluated.

- Radionuclide levels in soil do not exceed available Level 1 and 2 screening concentrations for terrestrial wildlife at the analogous sites.

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Figure C-1. Conceptual Exposure Model for the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units.

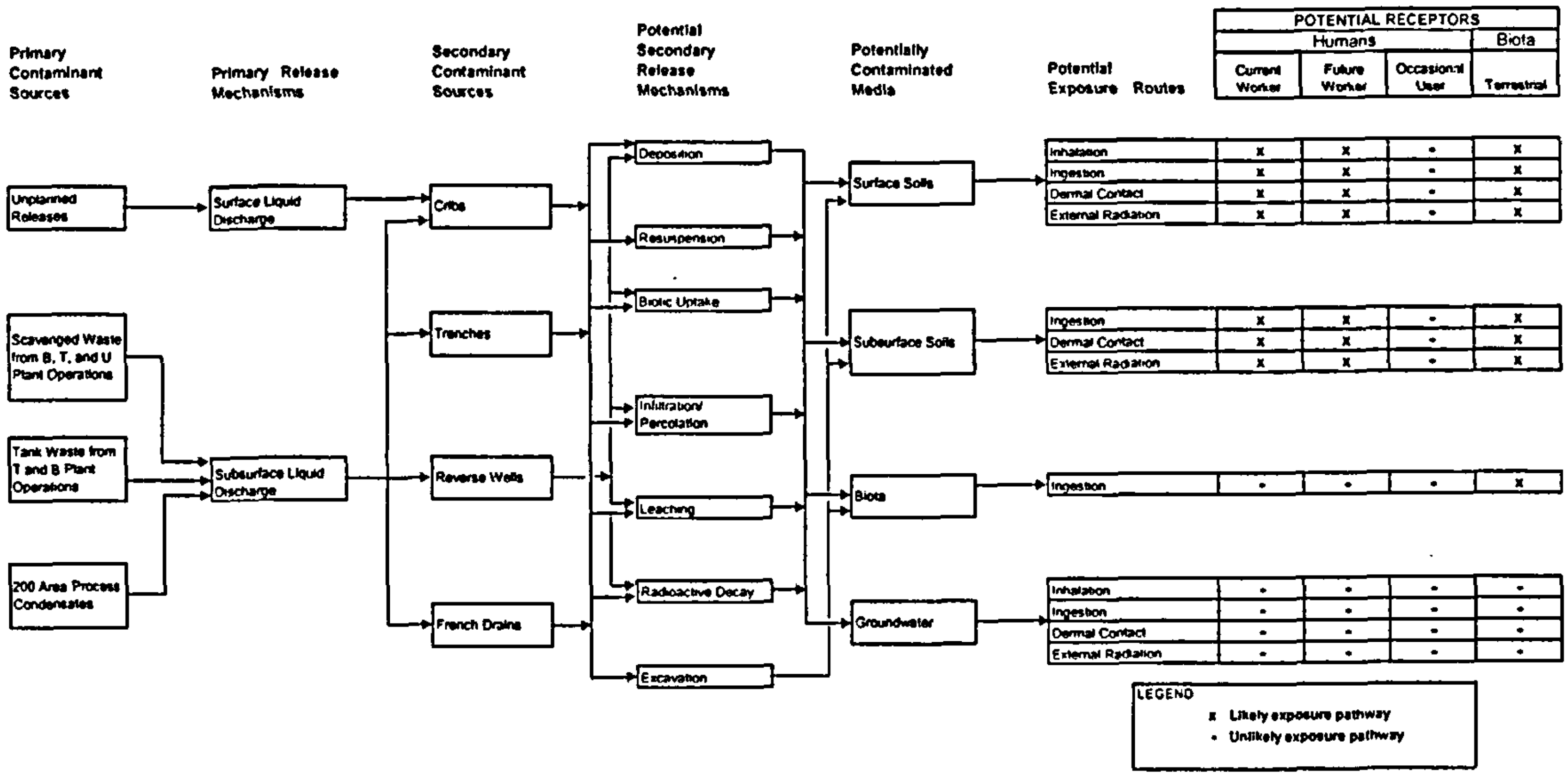
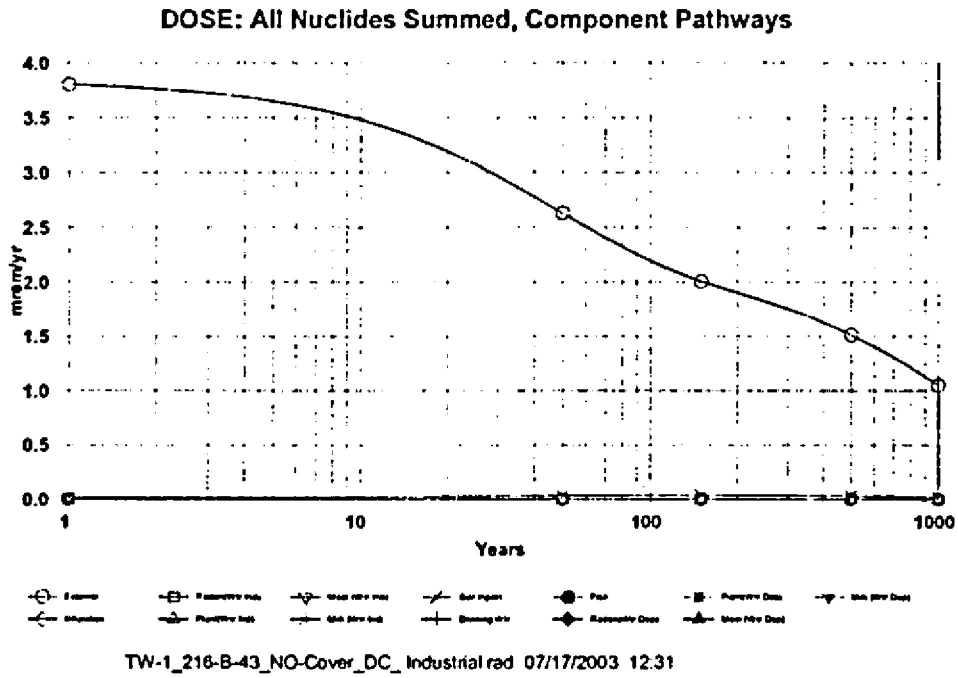


Figure C-2. . RESRAD Analysis for the 216-B-43 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



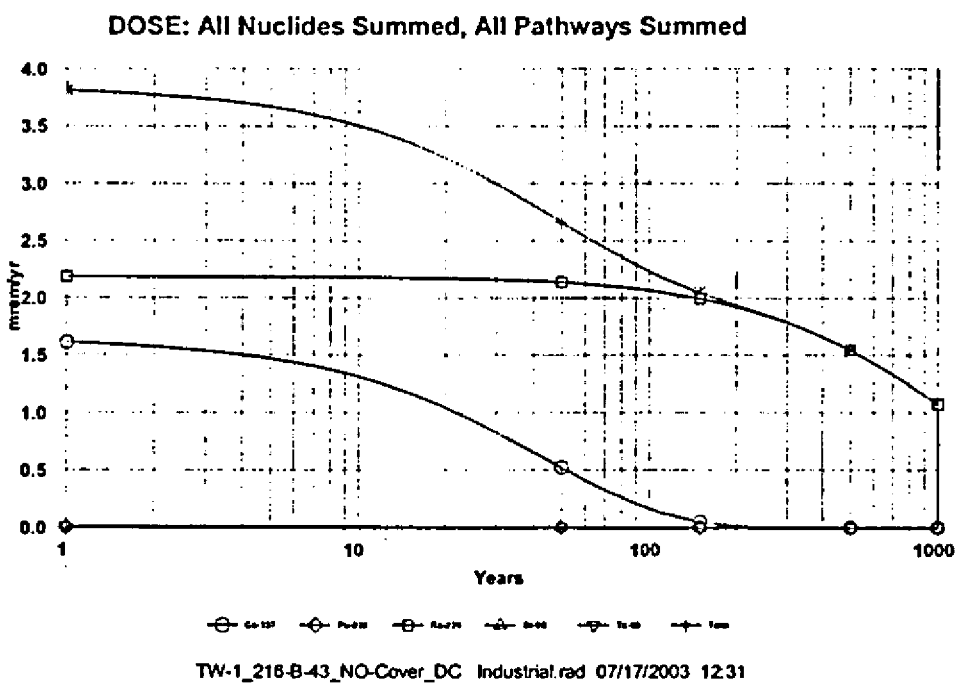
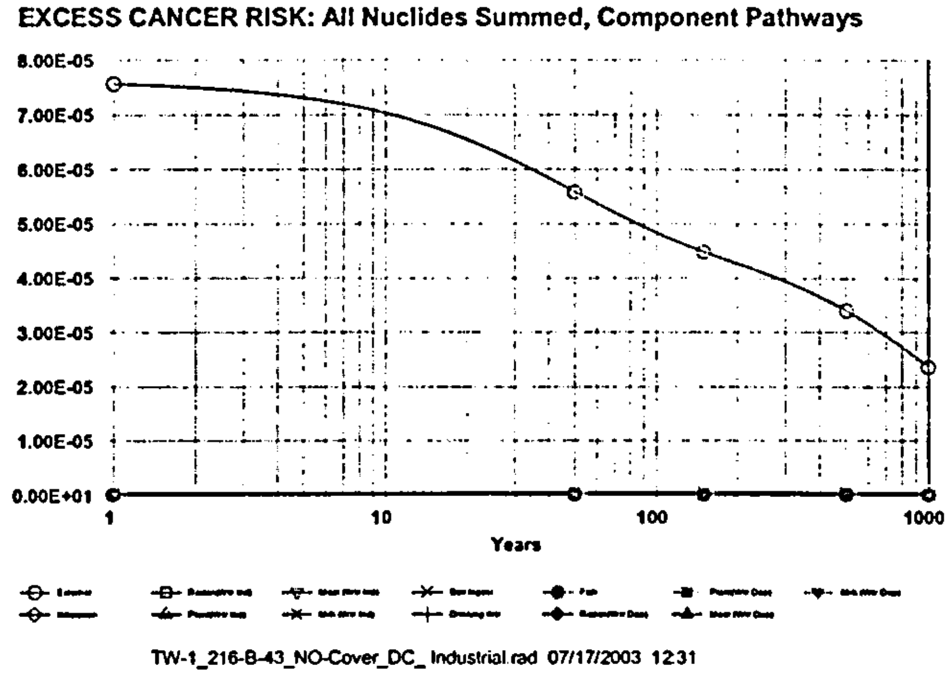


Figure C-3. RESRAD Analysis for the 216-B-43 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



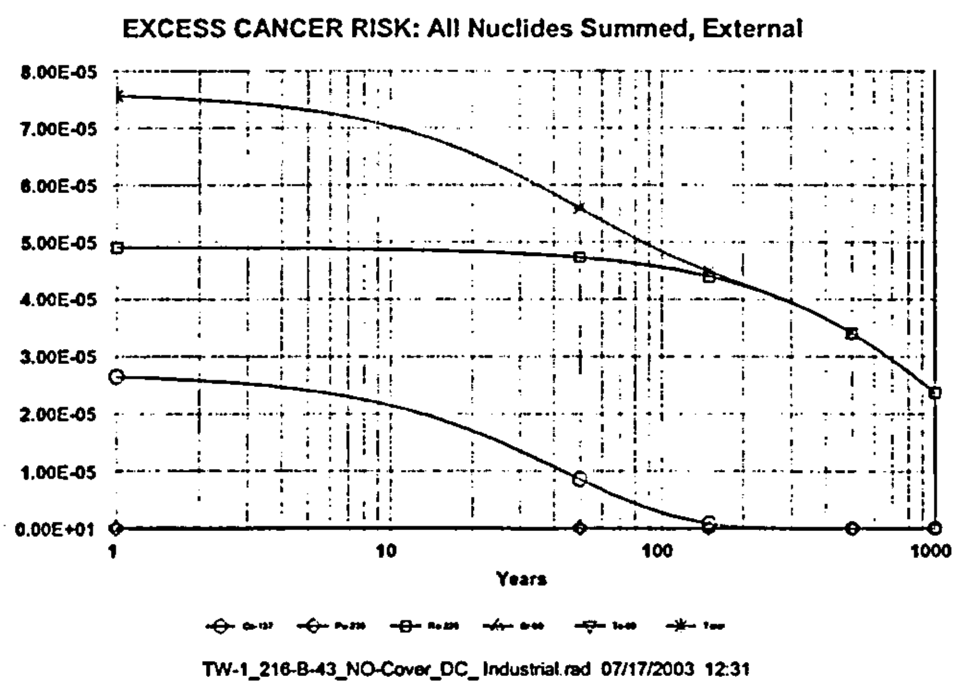
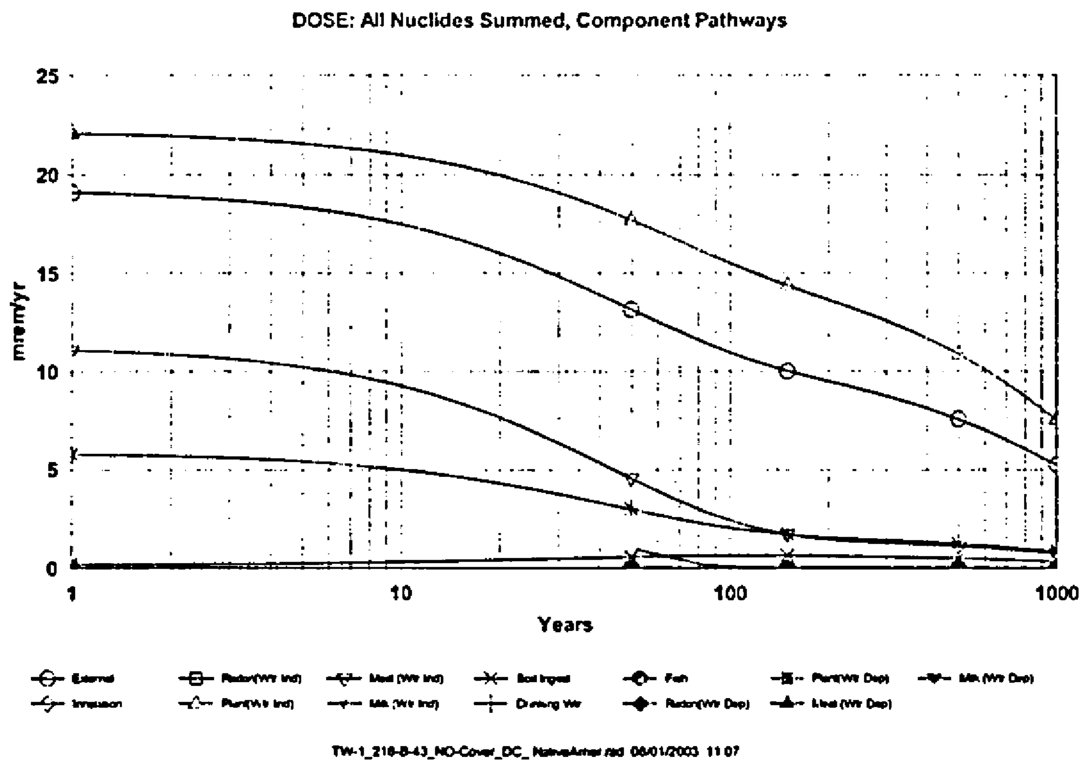


Figure C-4. RESRAD Analysis for the 216-B-43 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



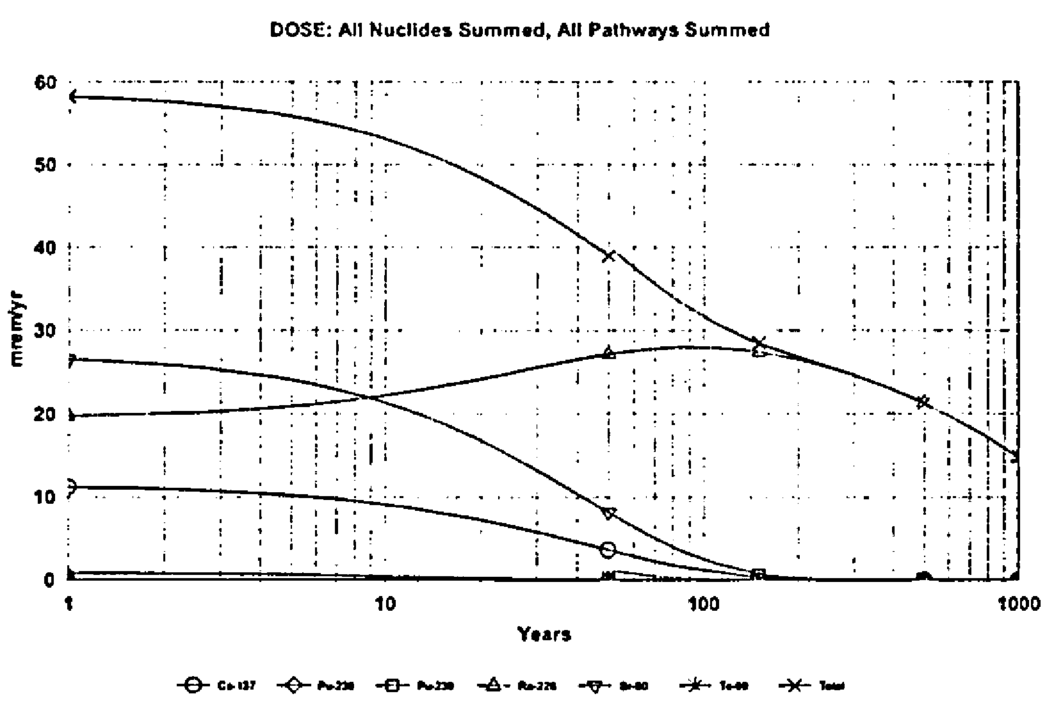
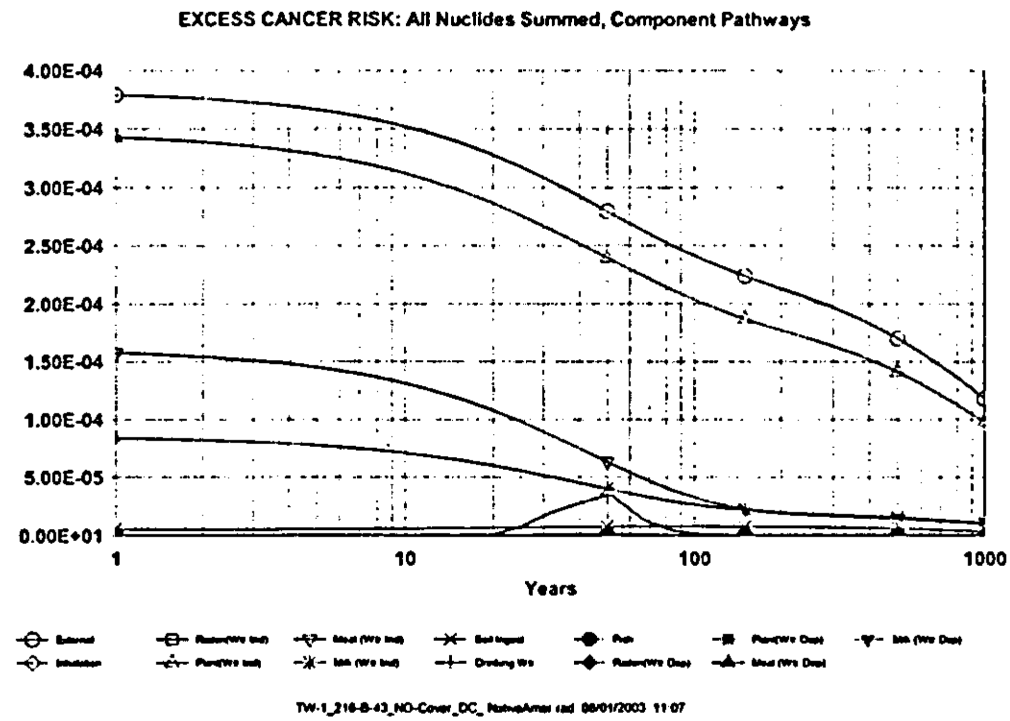


Figure C-5. RESRAD Analysis for the 216-B-43 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



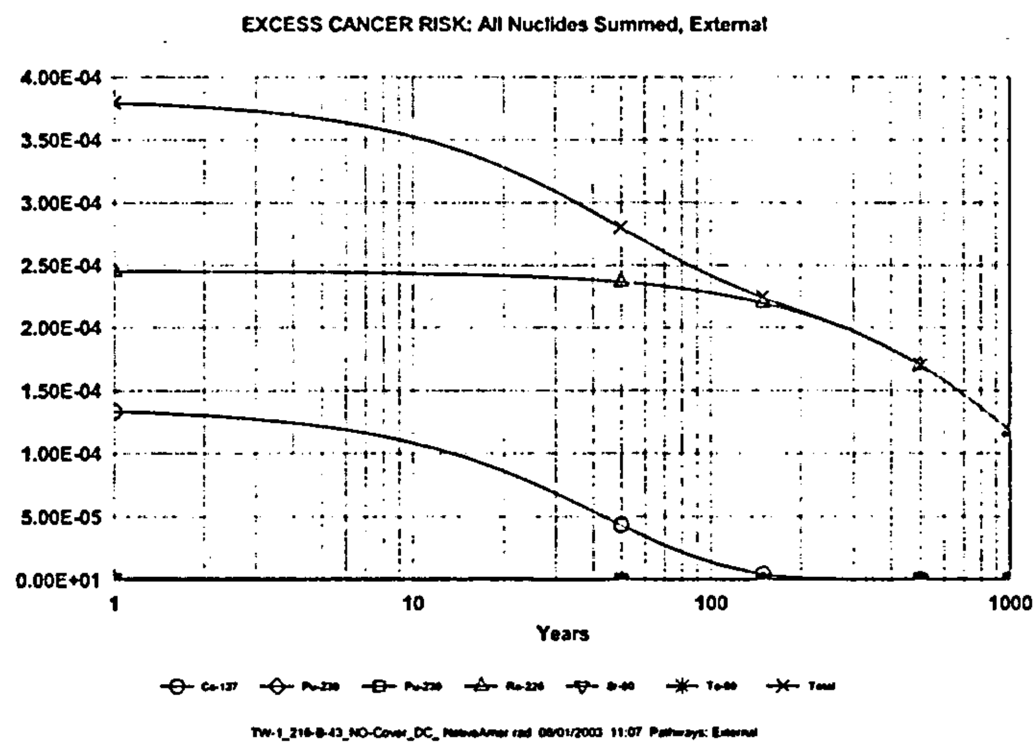
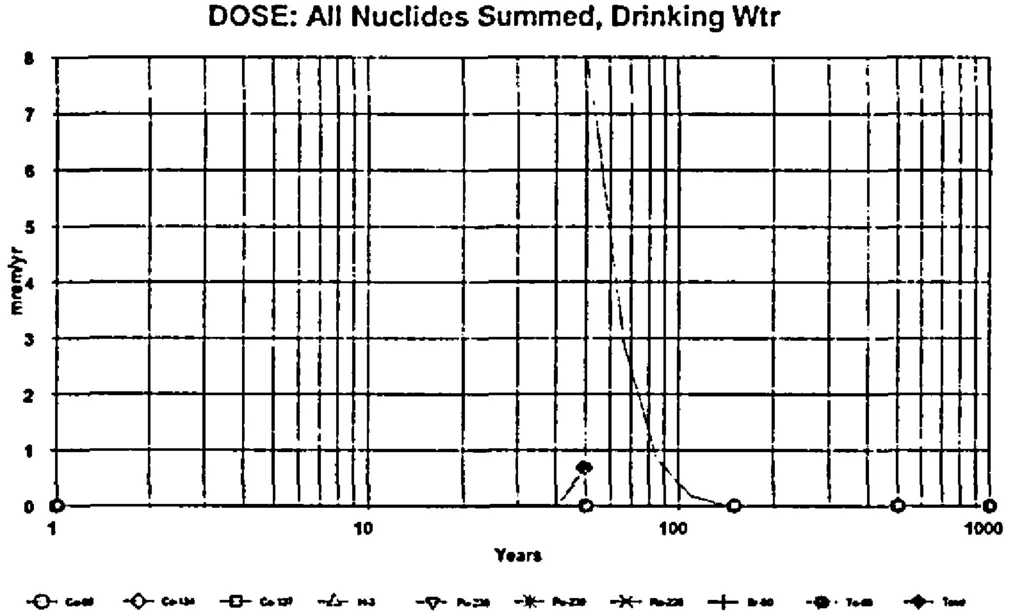


Figure C-6. RESRAD Analysis for the 216-B-43 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



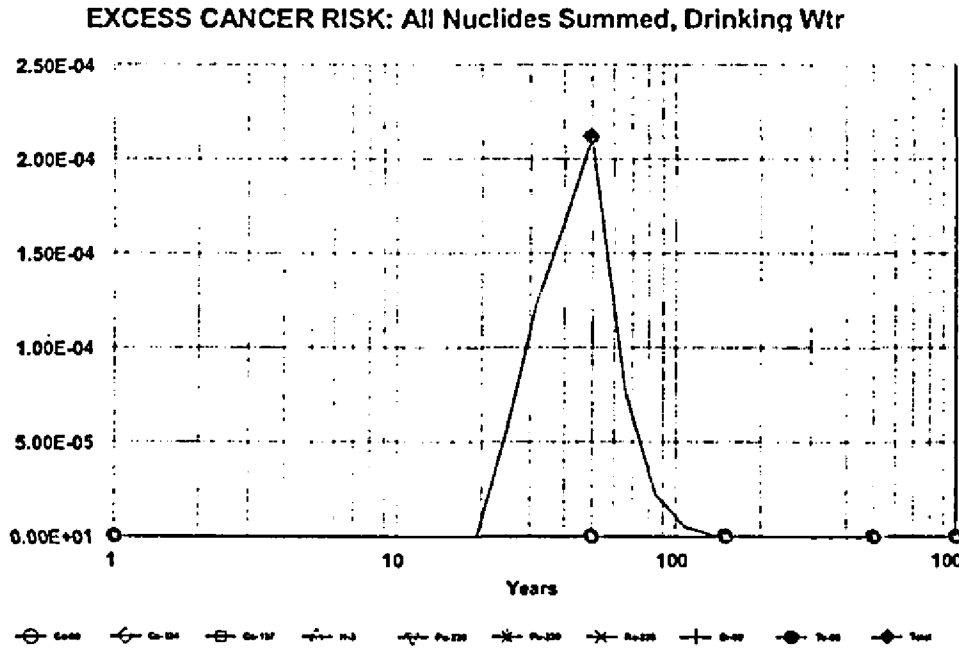
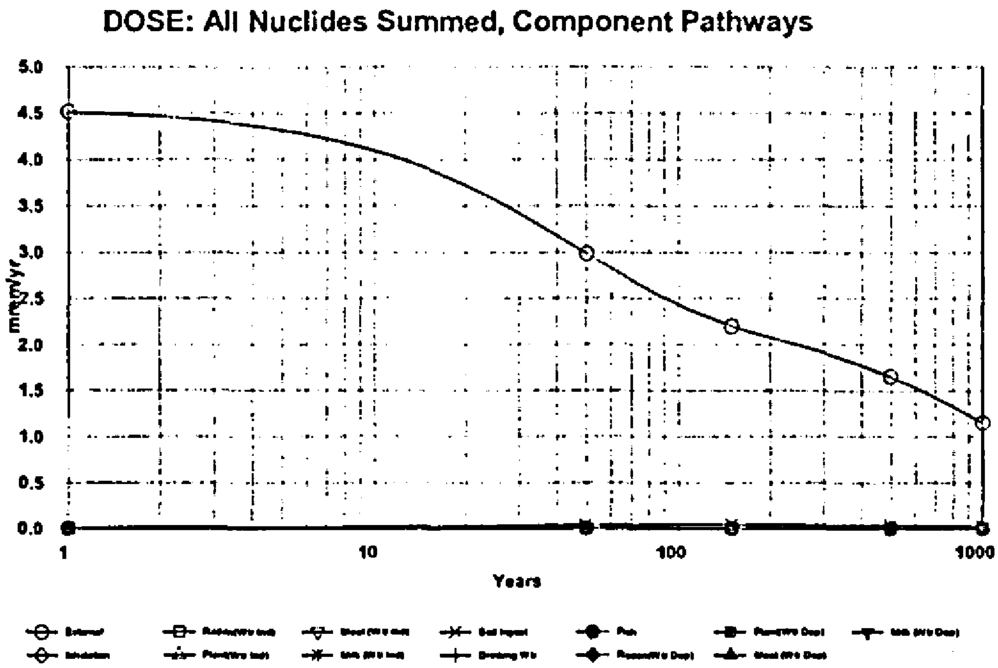


Figure C-7. RESRAD Analysis for 216-B-44 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



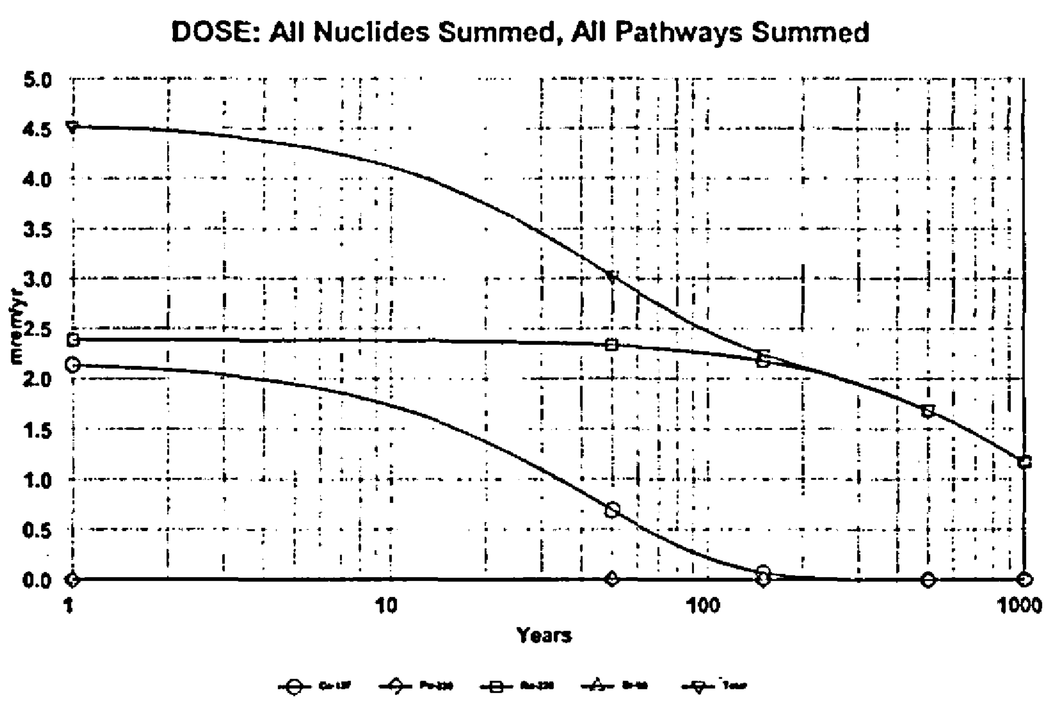
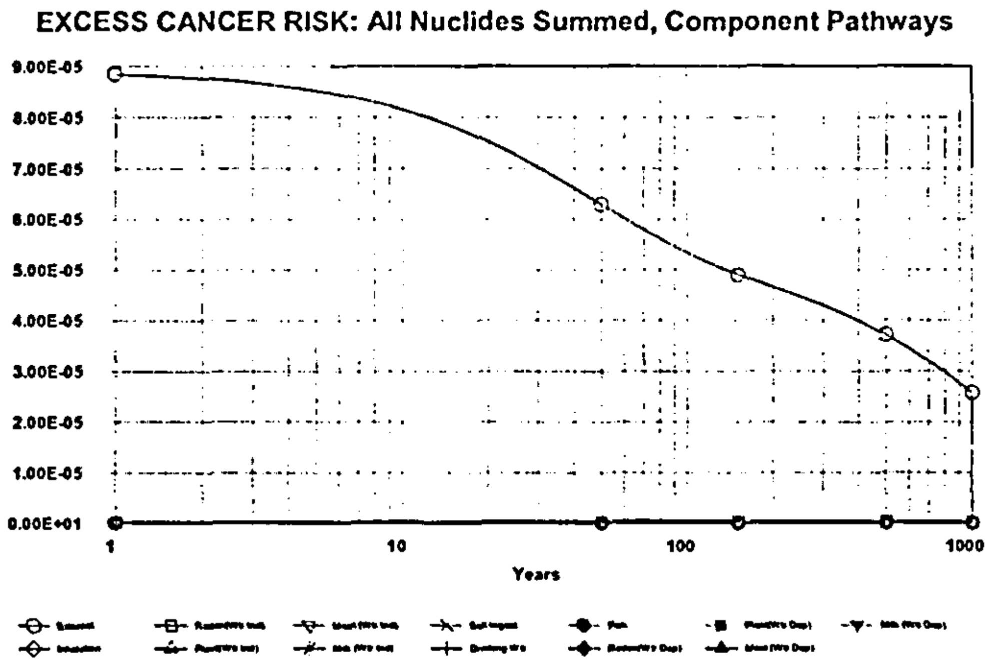


Figure C-8. RESRAD Analysis for 216-B-44 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



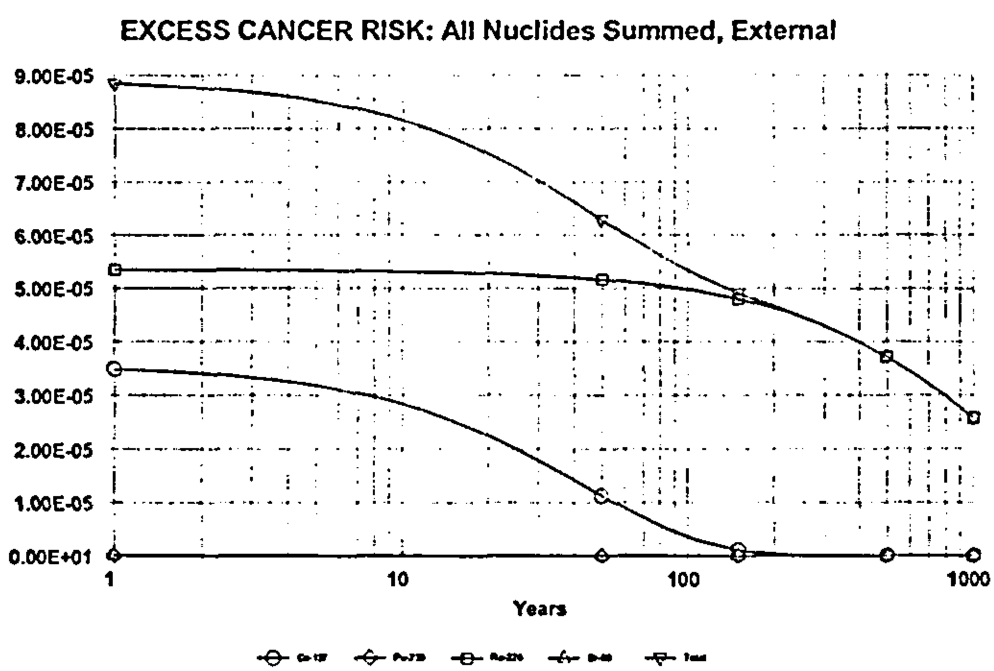
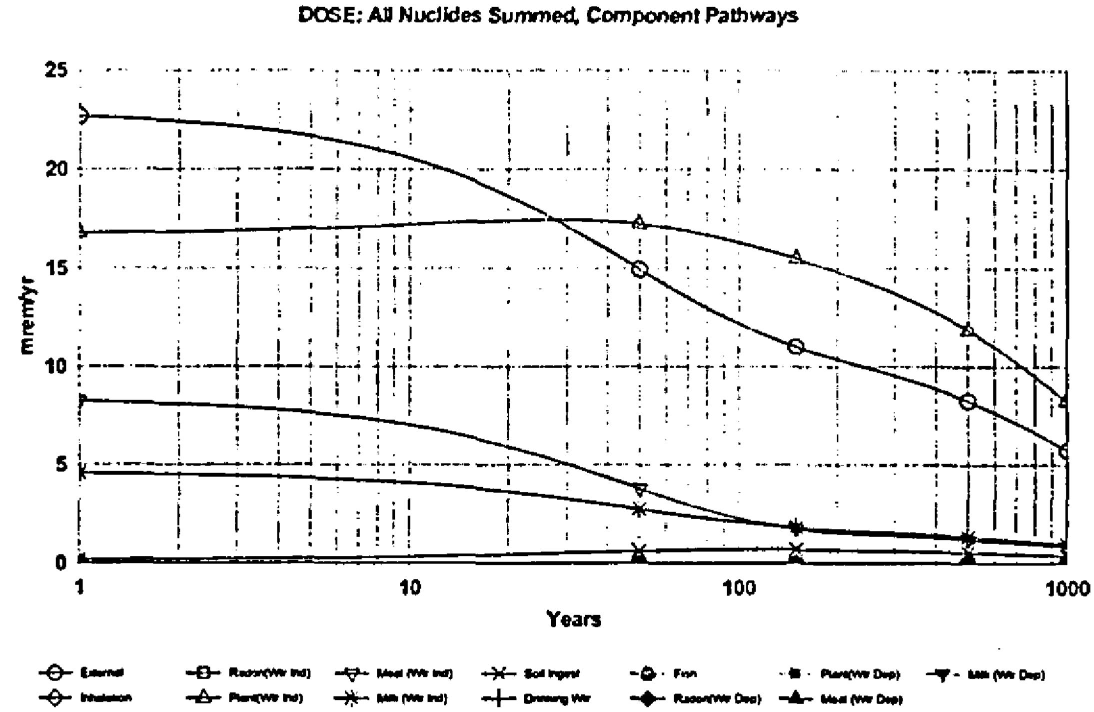


Figure C-9. RESRAD Analysis for 216-B-44 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



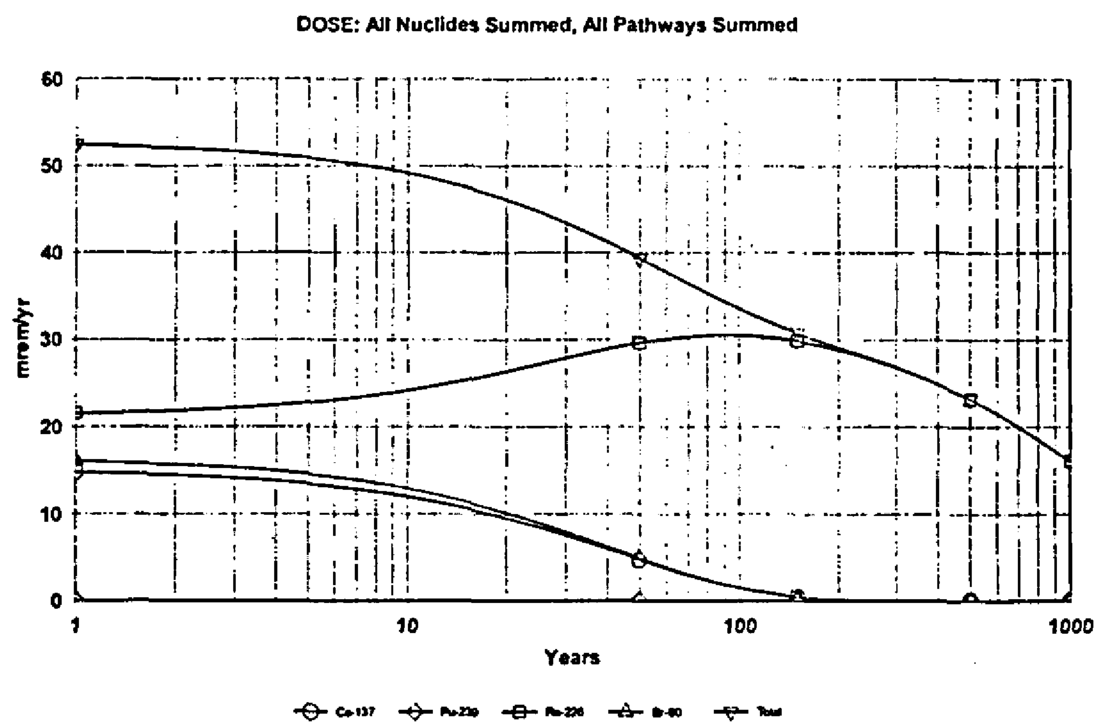
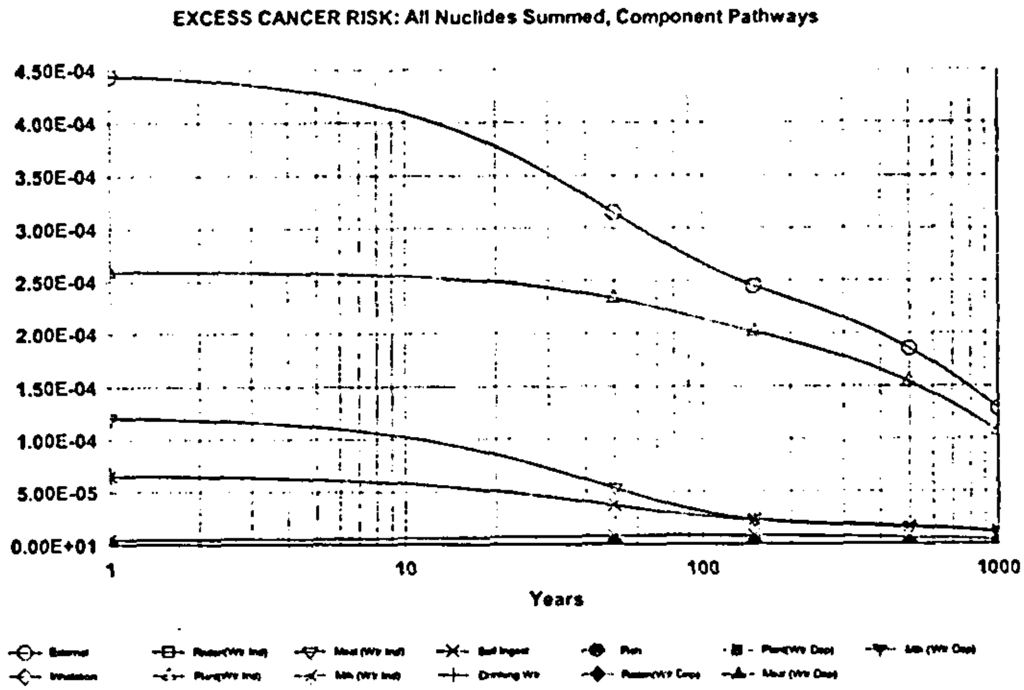


Figure C-10. RESRAD Analysis for 216-B-44 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



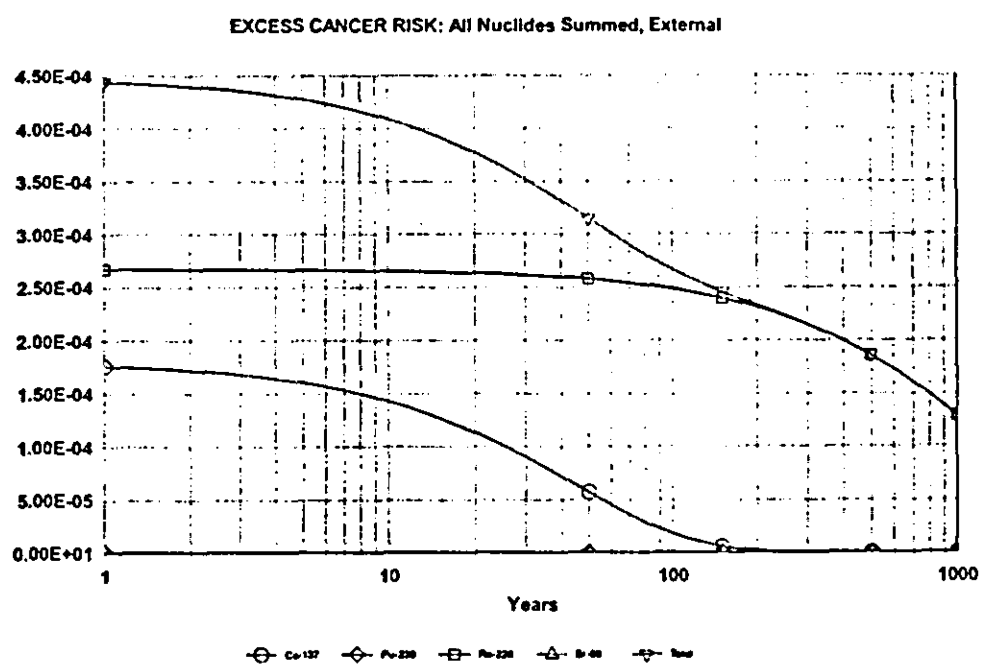
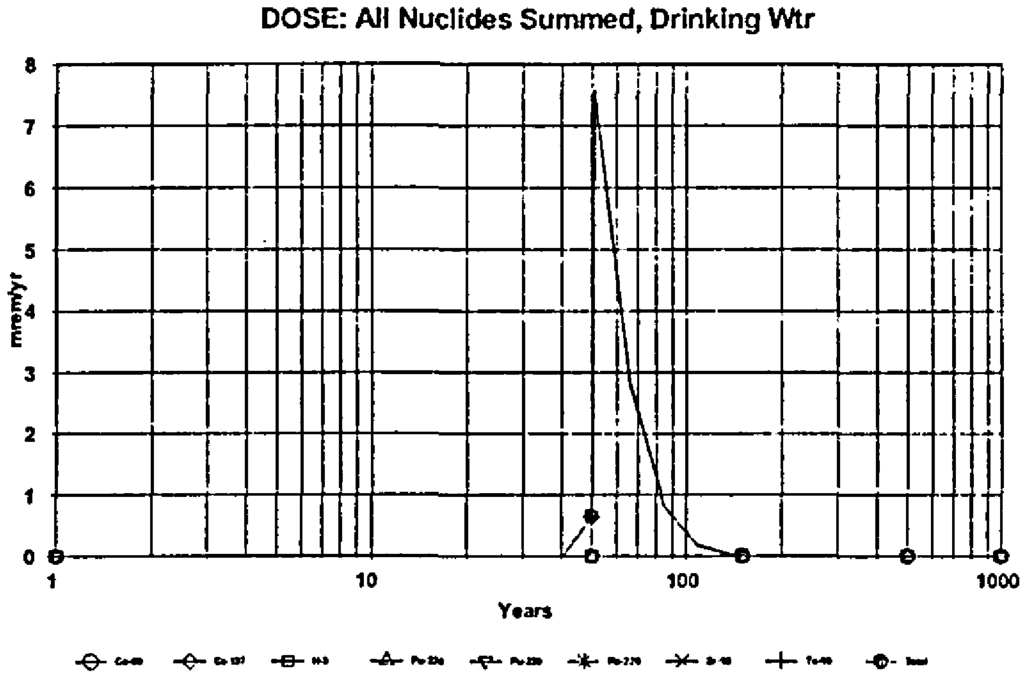


Figure C-11. RESRAD Analysis for 216-B-44 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



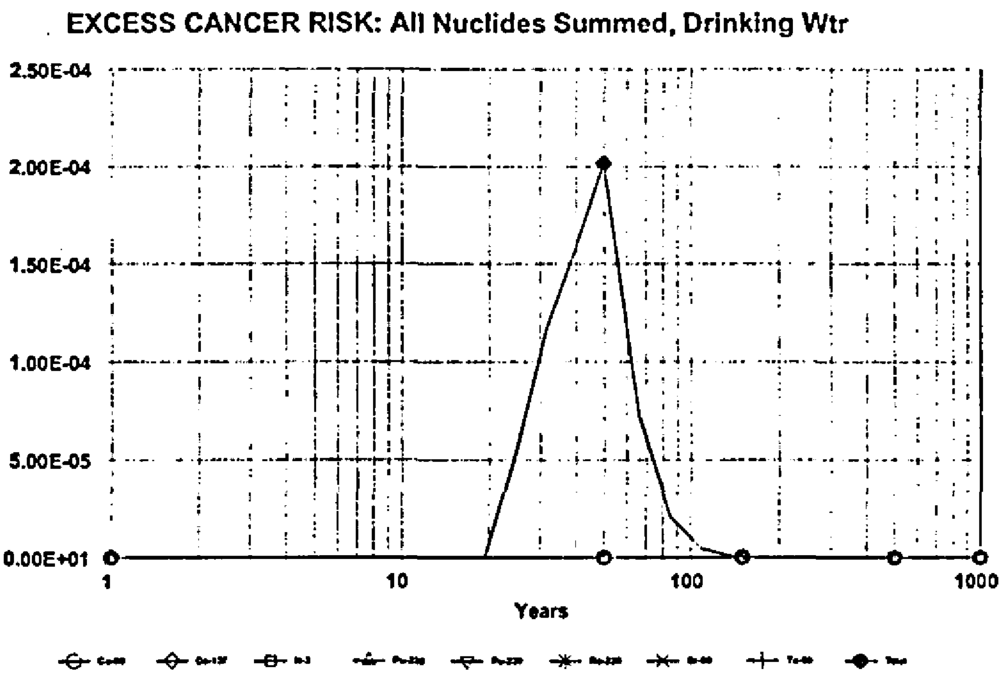
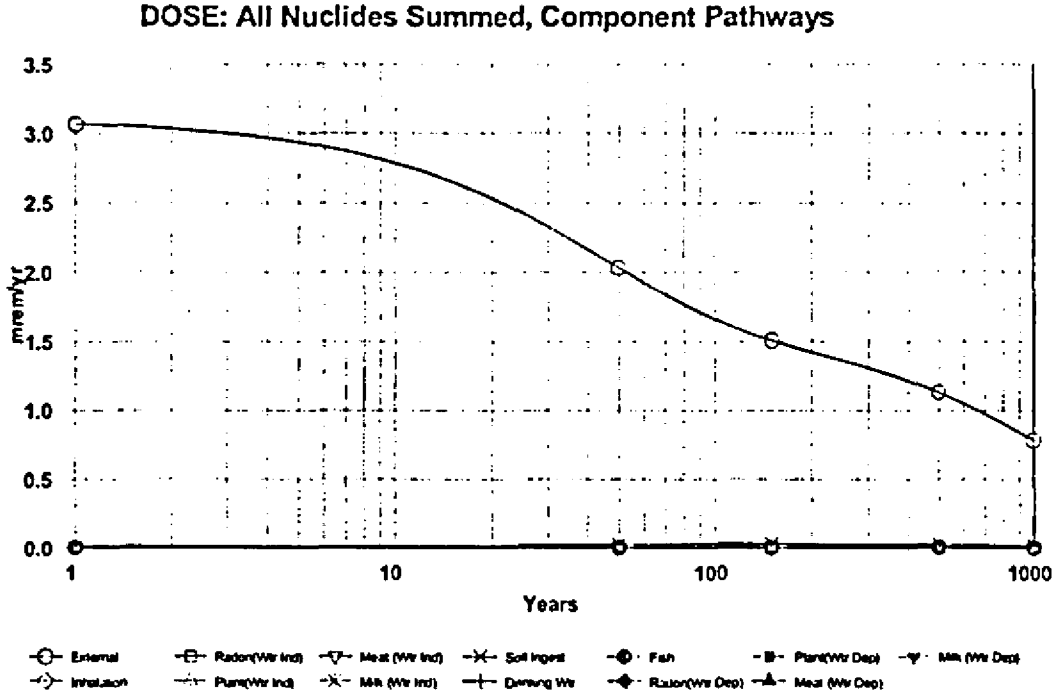


Figure C-12. RESRAD Analysis for 216-B-45 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



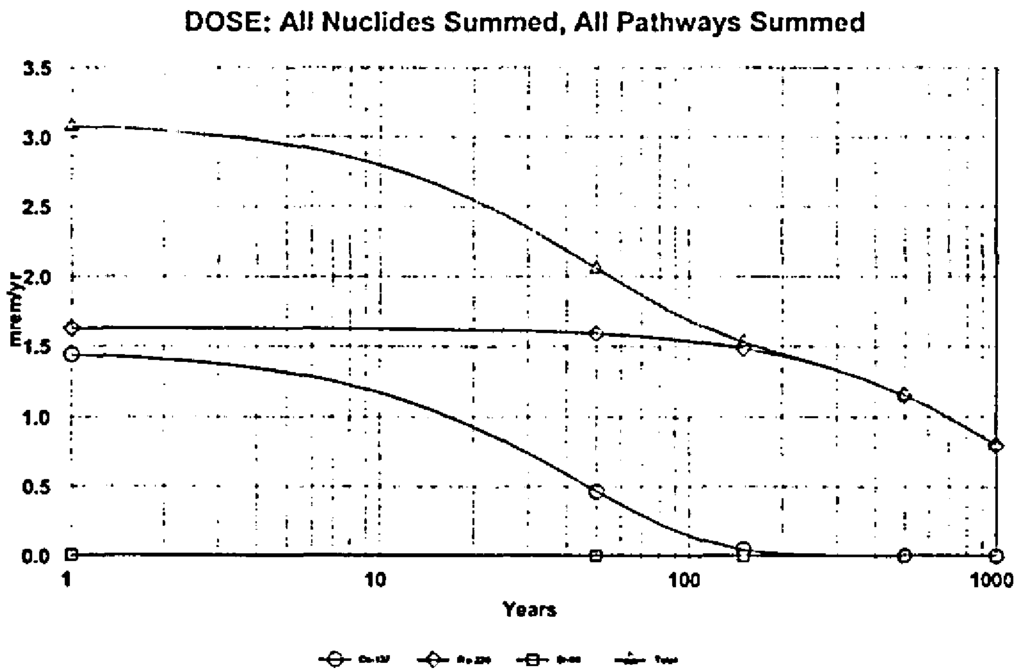
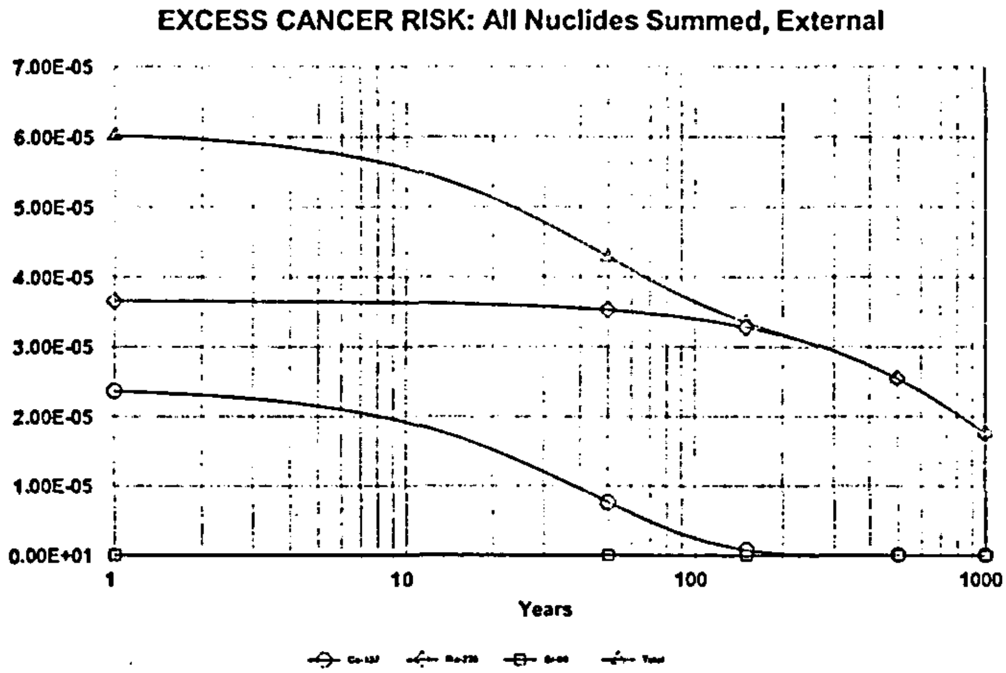


Figure C- 13. RESRAD Analysis for 216-B-45 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



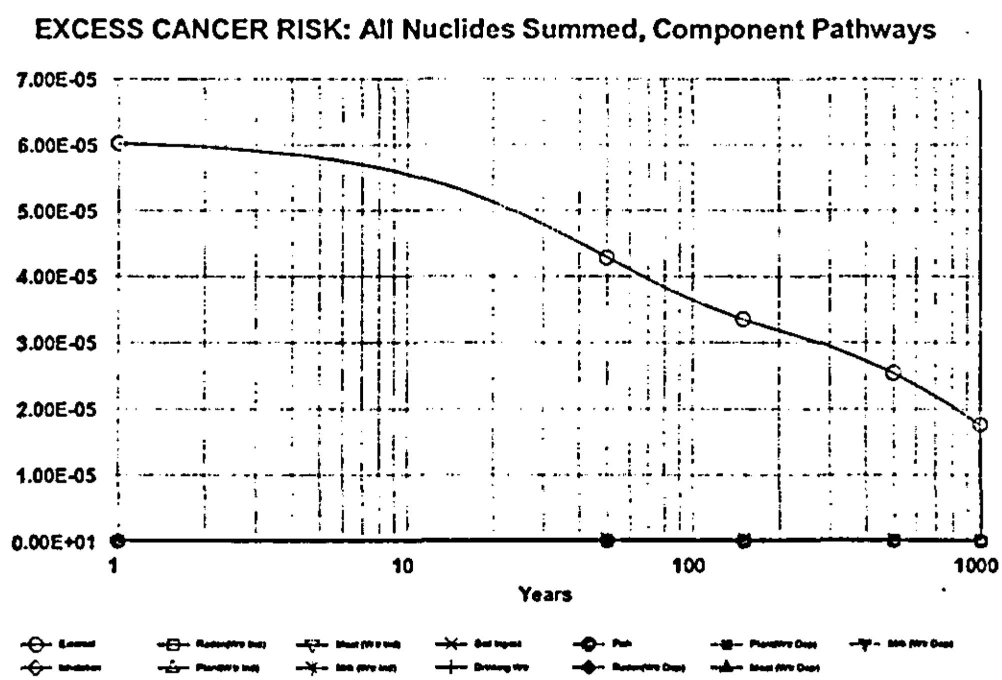
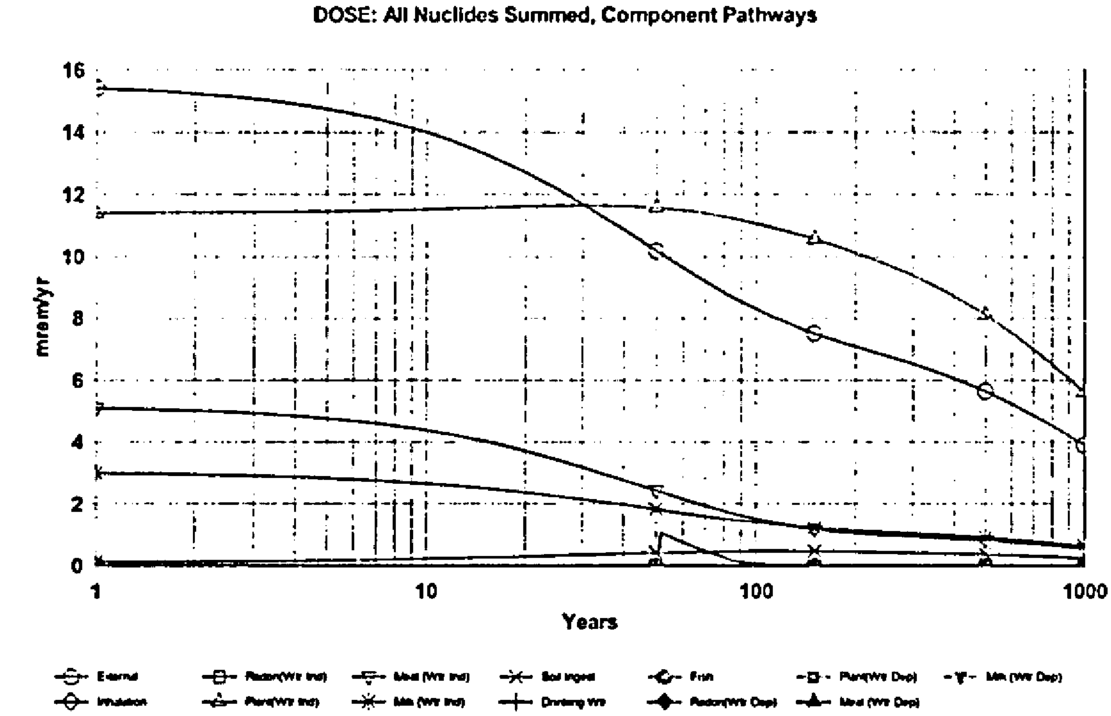


Figure C-14. RESRAD Analysis for 216-B-45 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



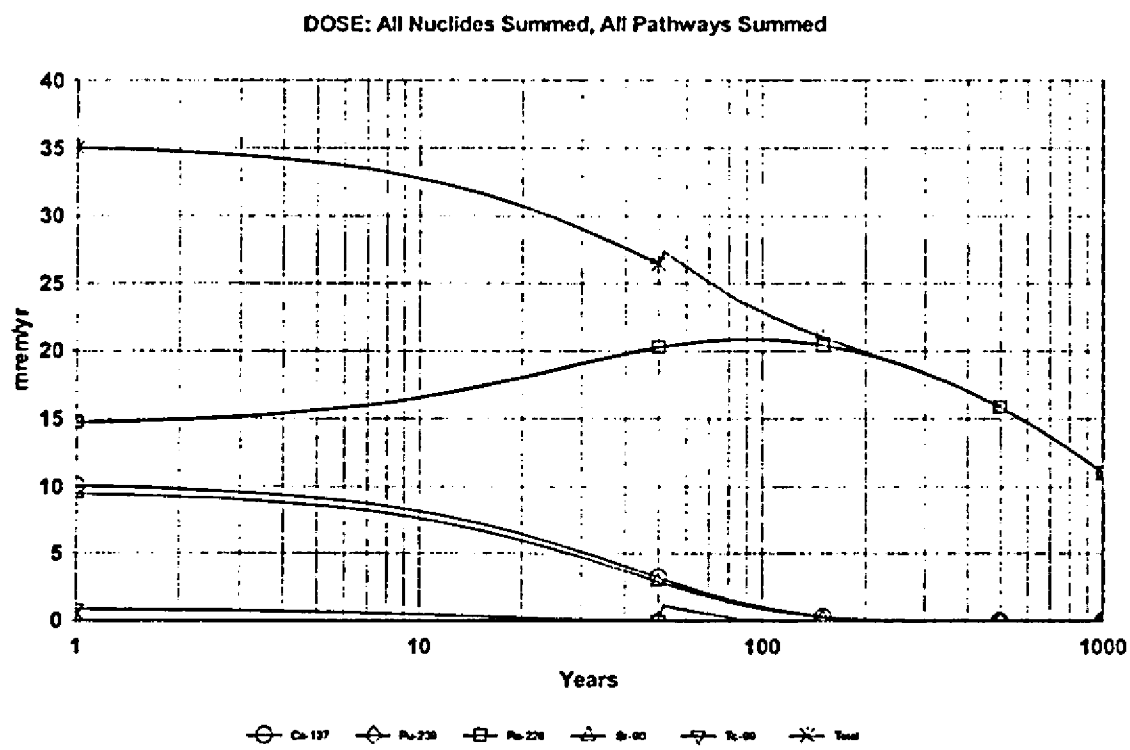
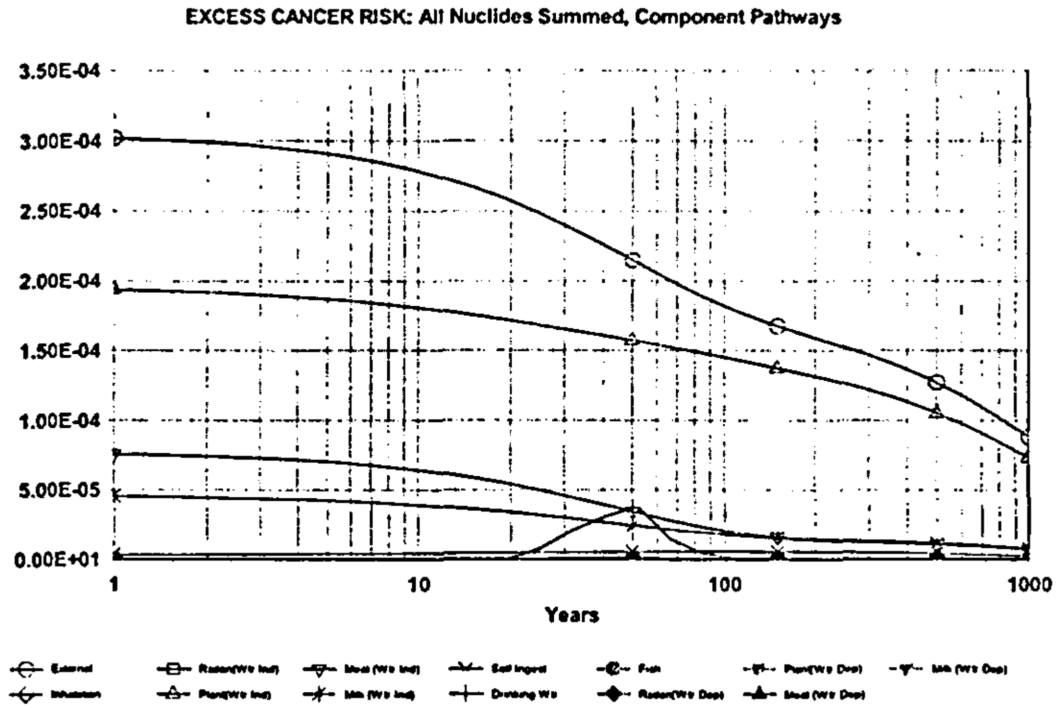


Figure C-15. RESRAD Analysis for 216-B-45 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



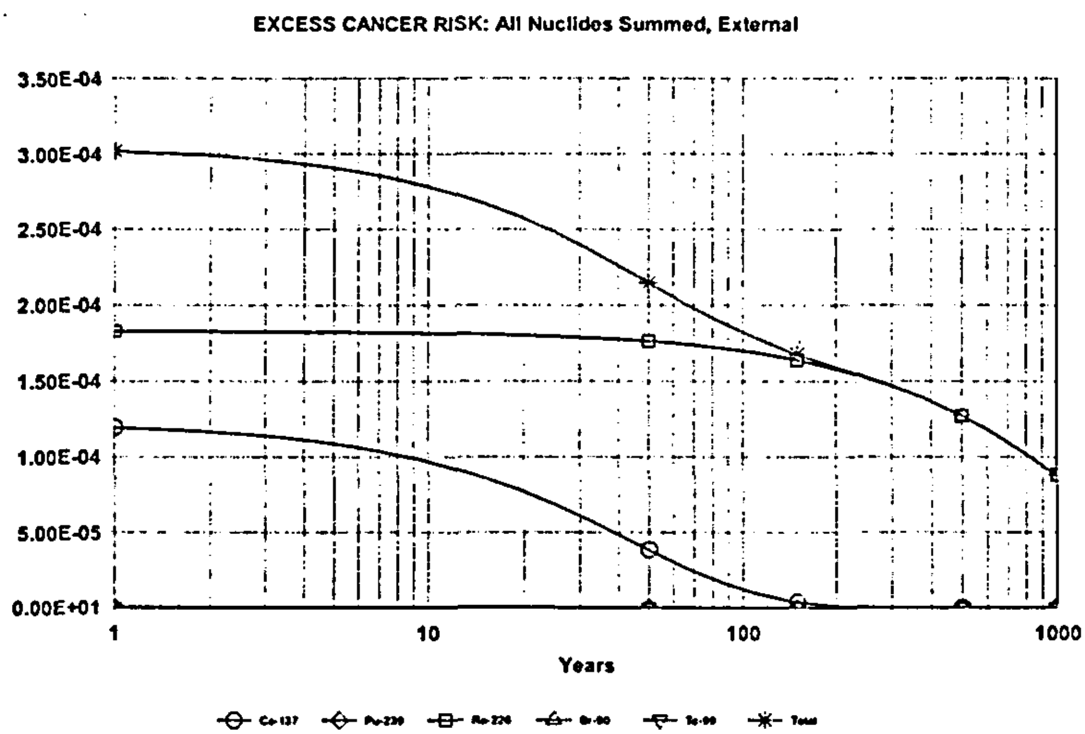
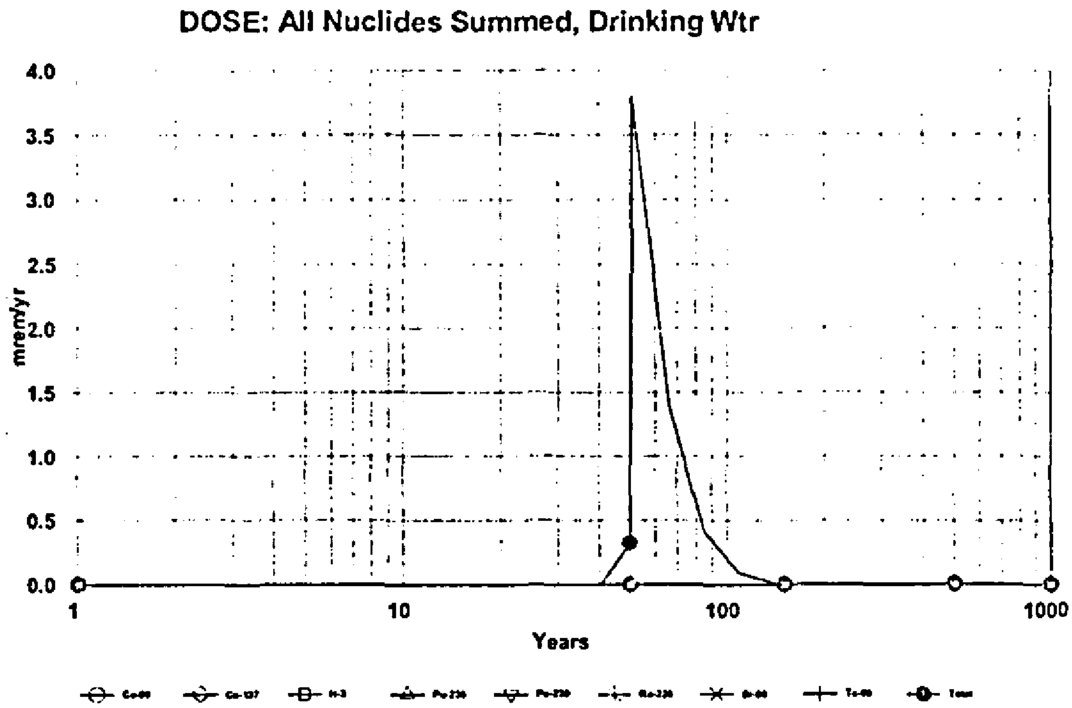


Figure C-16. RESRAD Analysis for 216-B-45 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



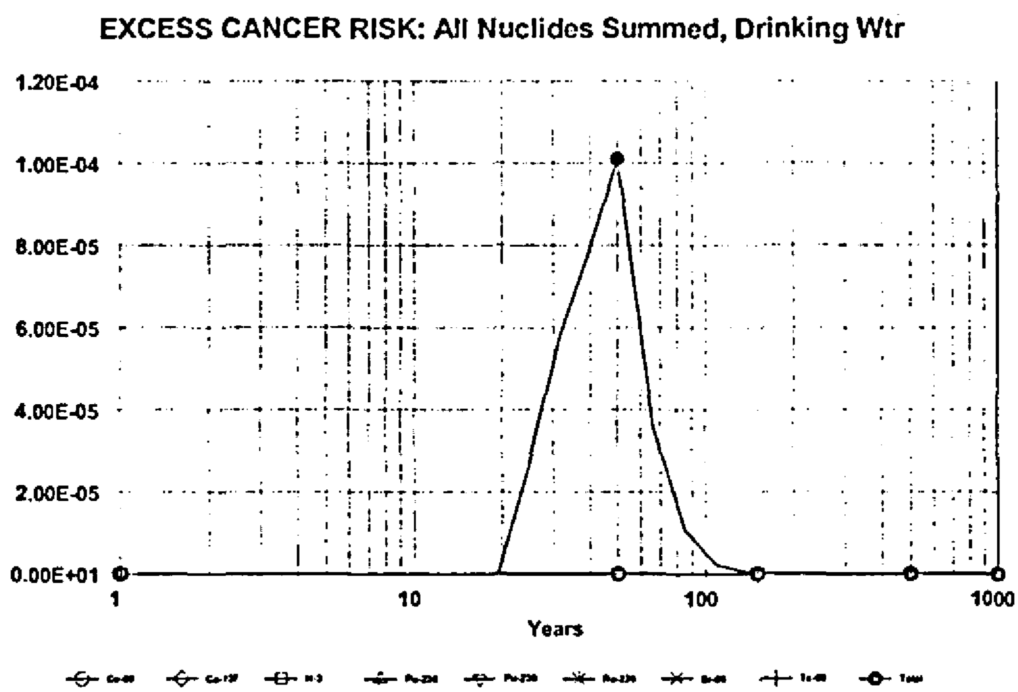
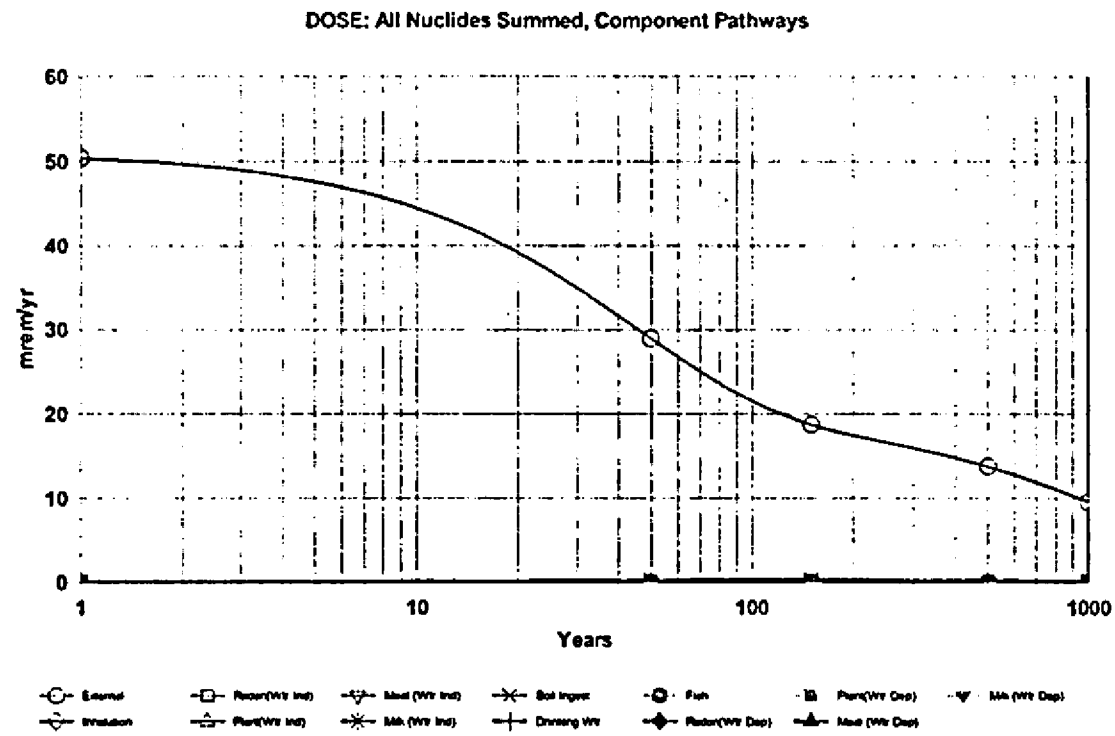


Figure C-17. RESRAD Analysis for 216-B-47 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



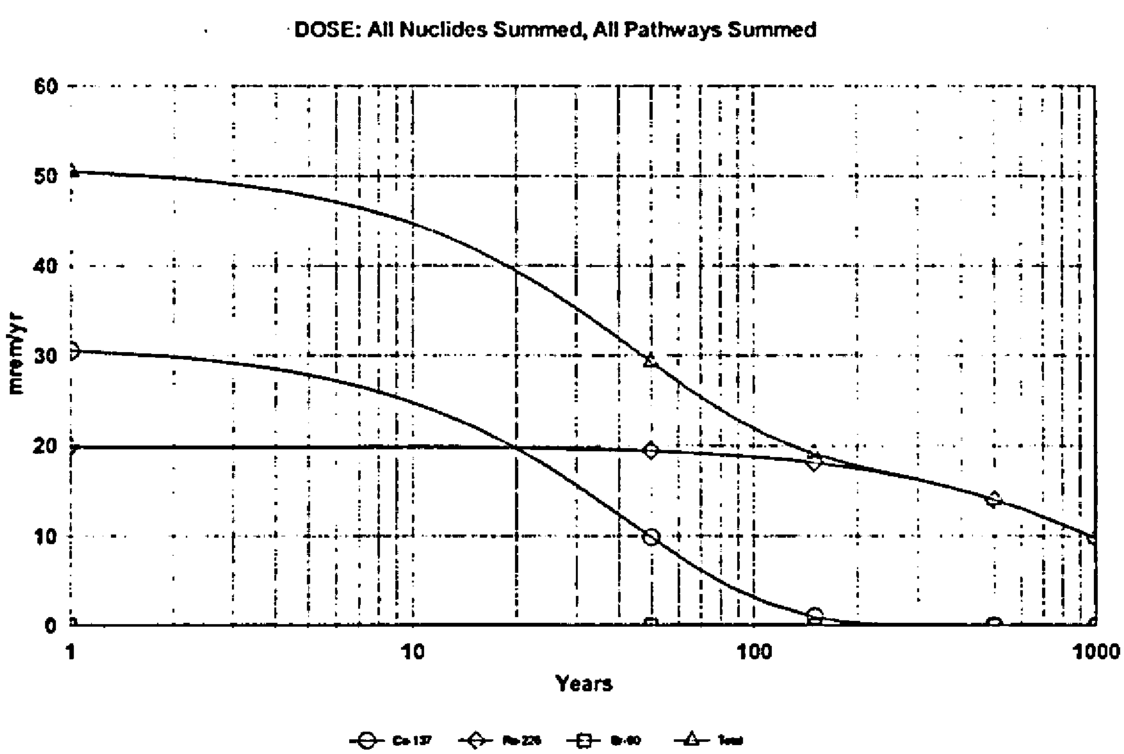
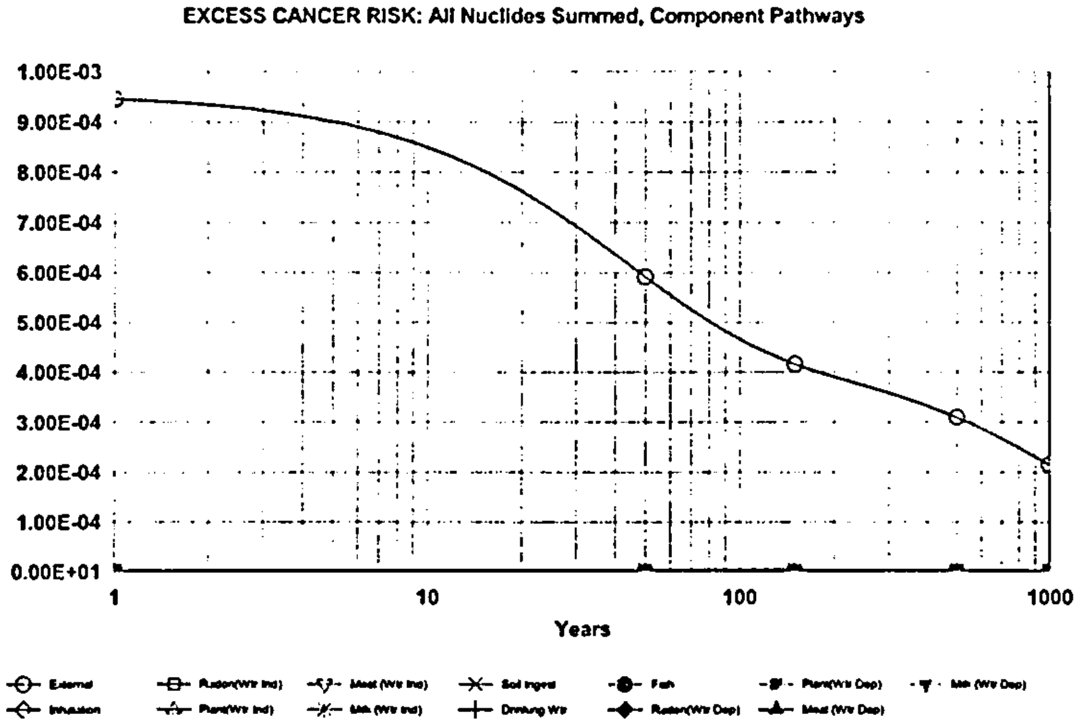


Figure C-18. RESRAD Analysis for 216-B-47 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



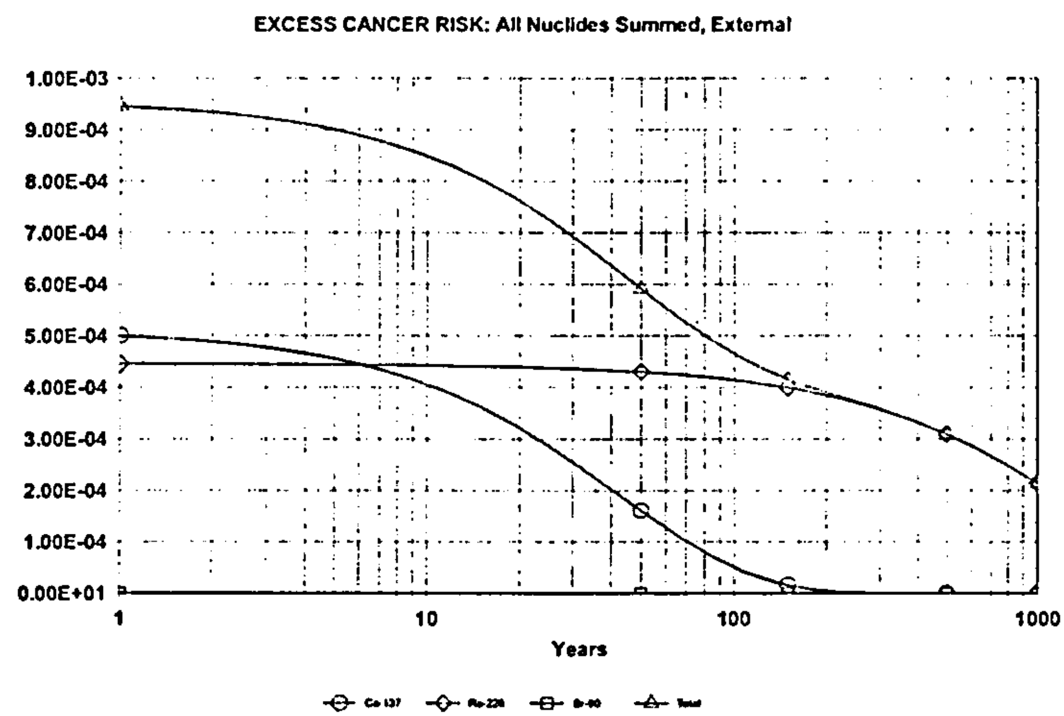
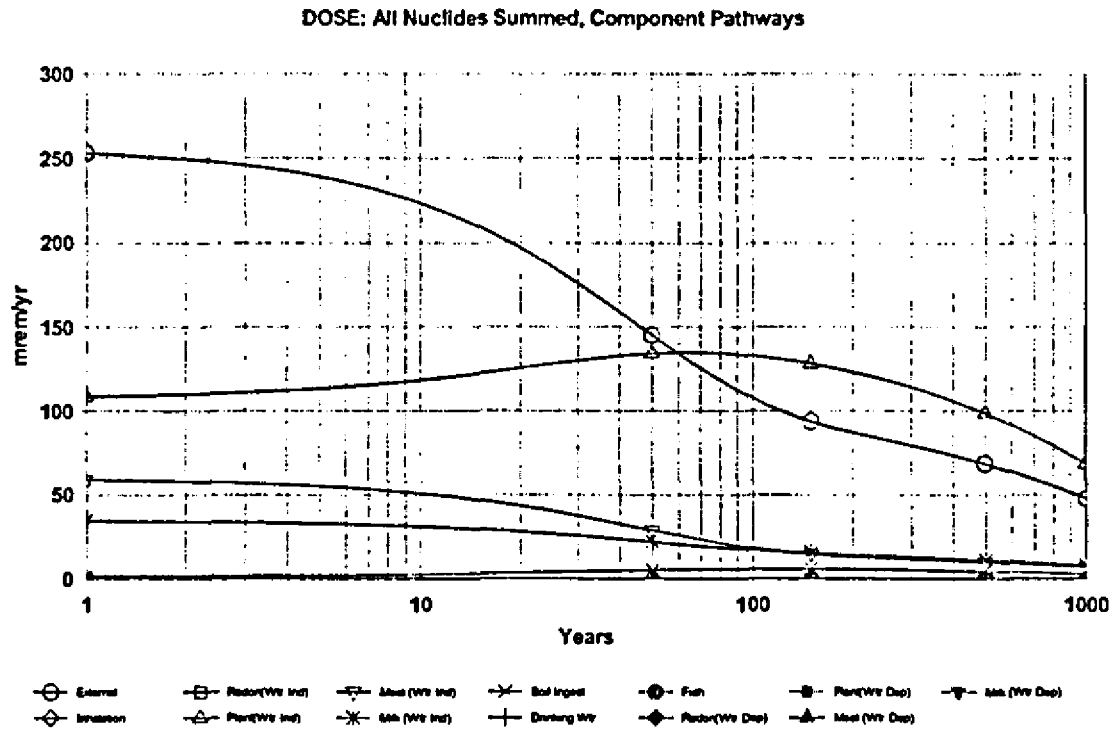


Figure C-19. RESRAD Analysis for 216-B-47 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



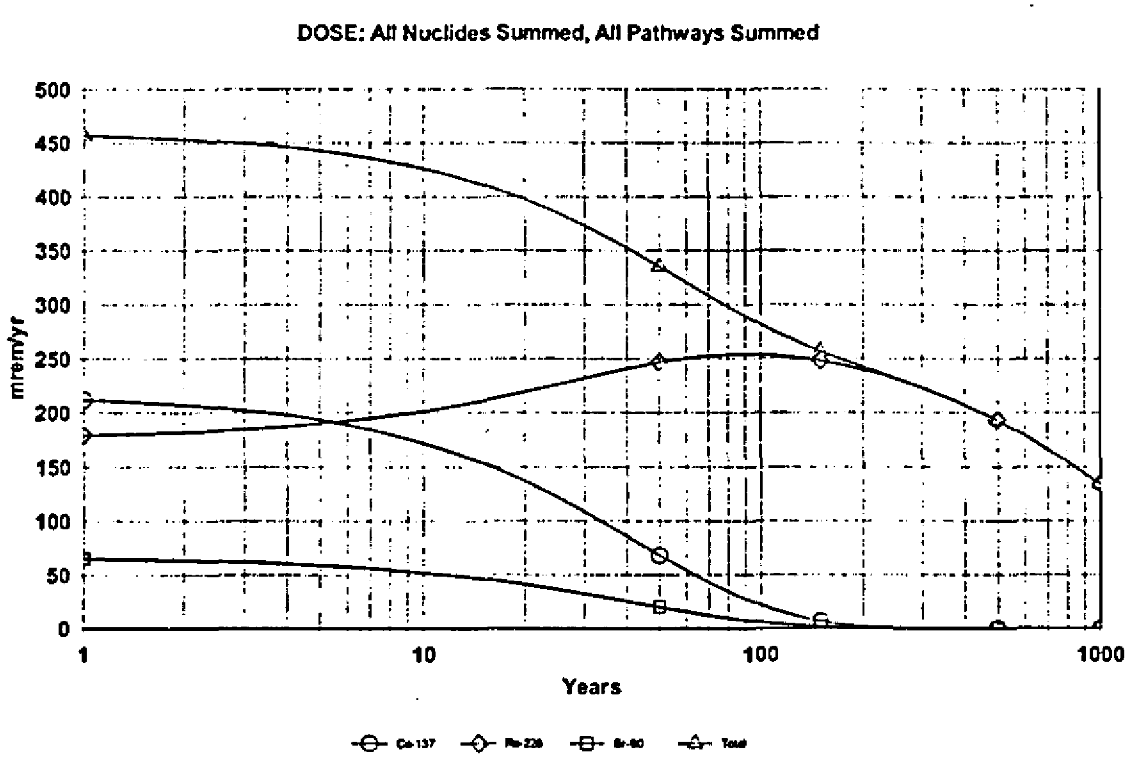
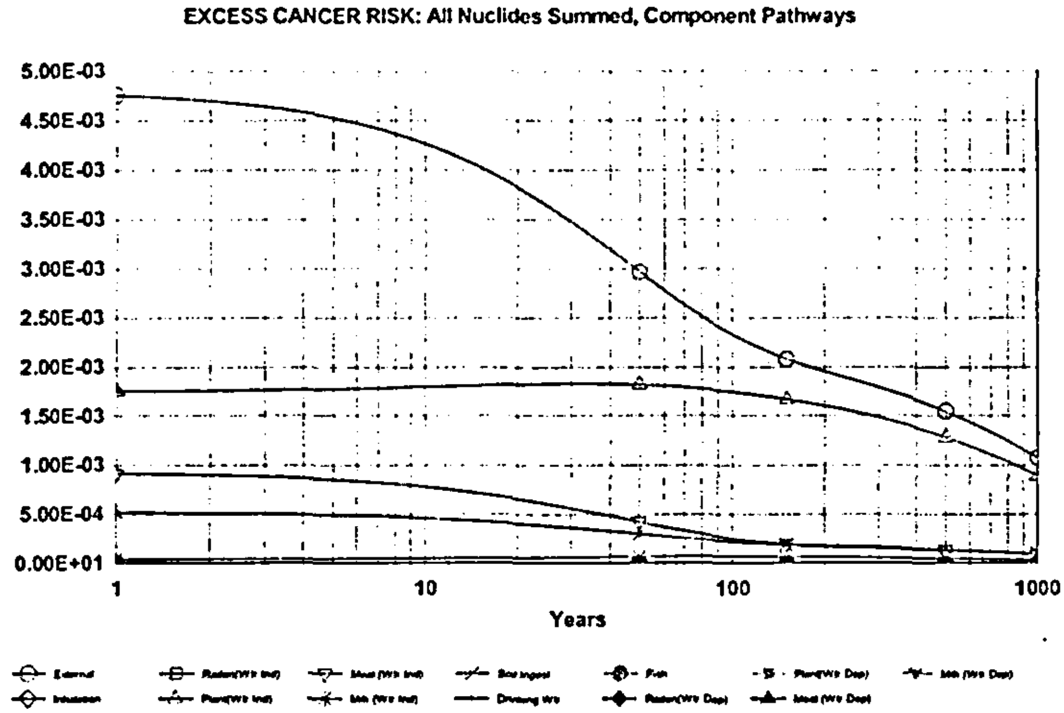


Figure C-20. RESRAD Analysis for 216-B-47 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



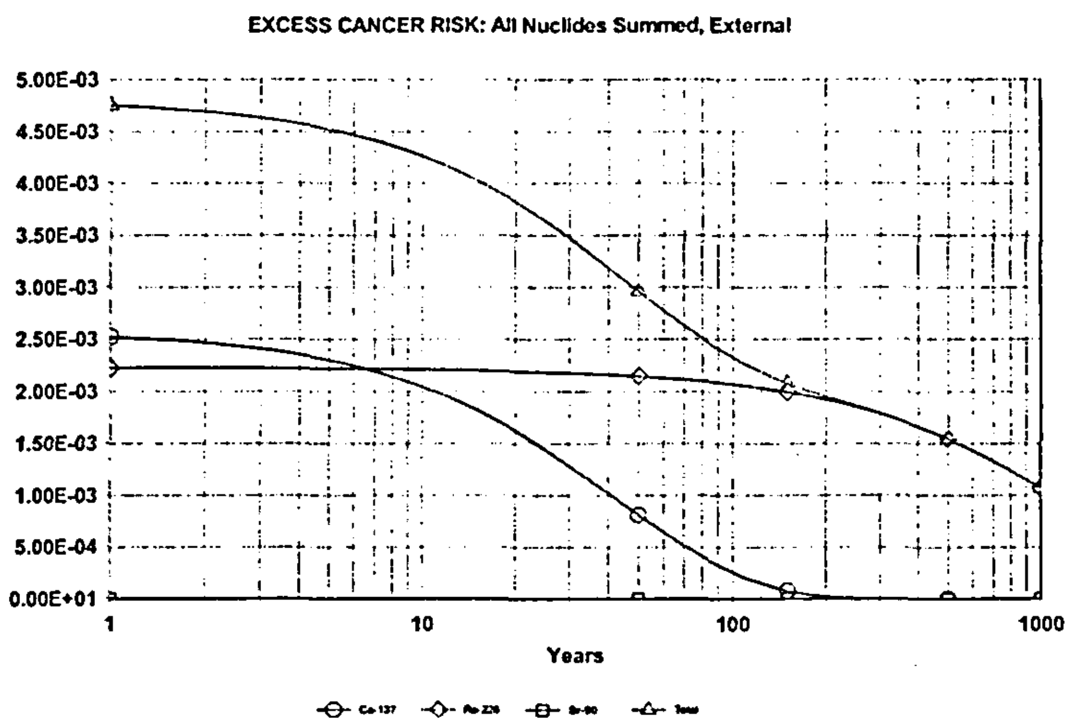


Figure C- 21. RESRAD Analysis for 216-B-47 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).

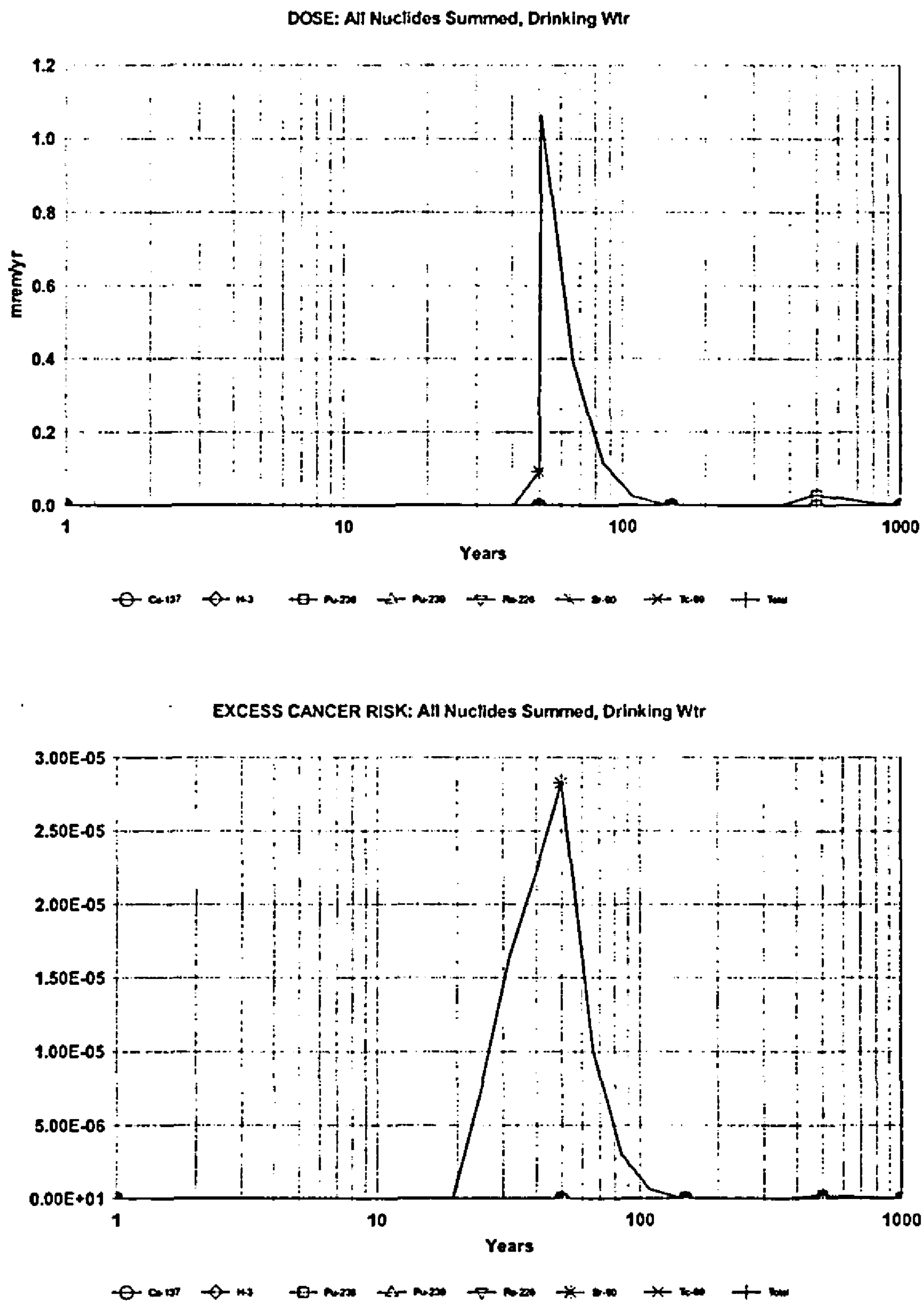
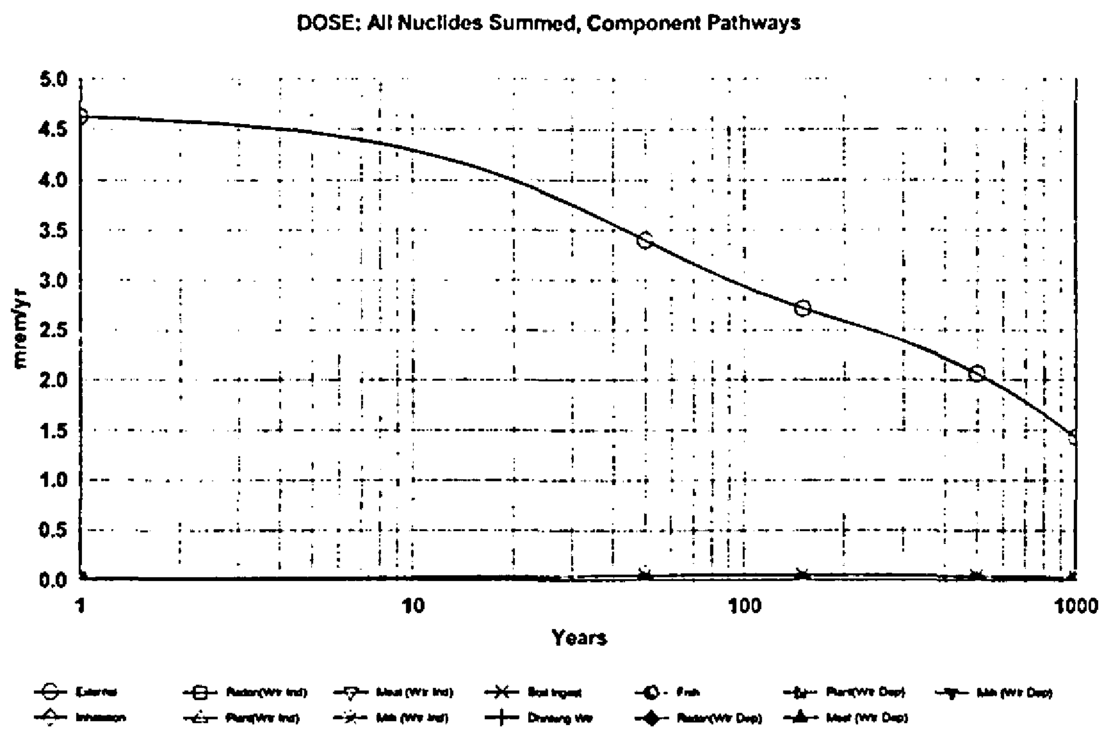


Figure C-22. RESRAD Analysis for 216-B-48 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



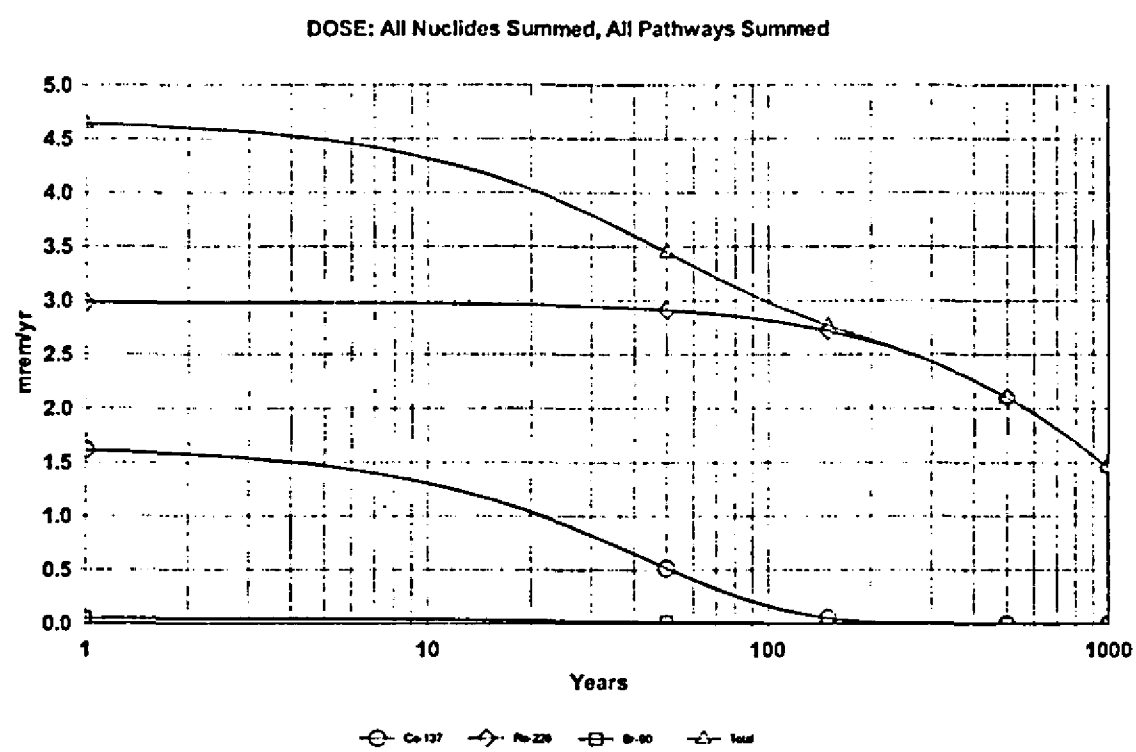
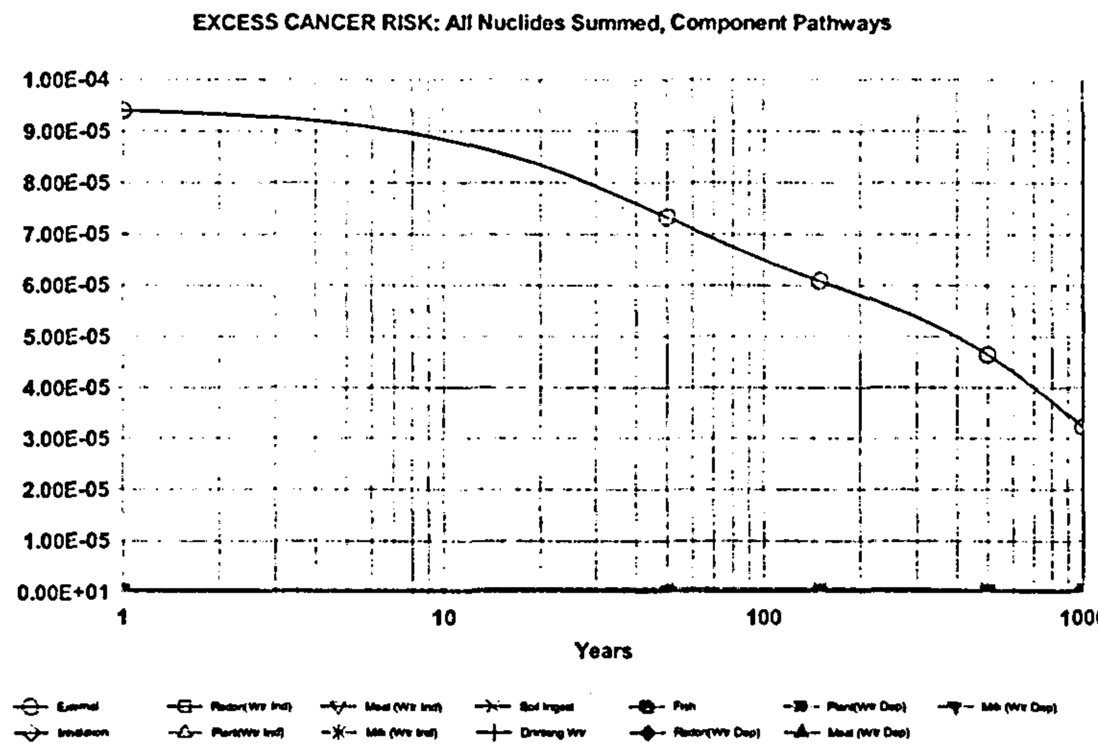


Figure C-23. RESRAD Analysis for 216-B-48 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



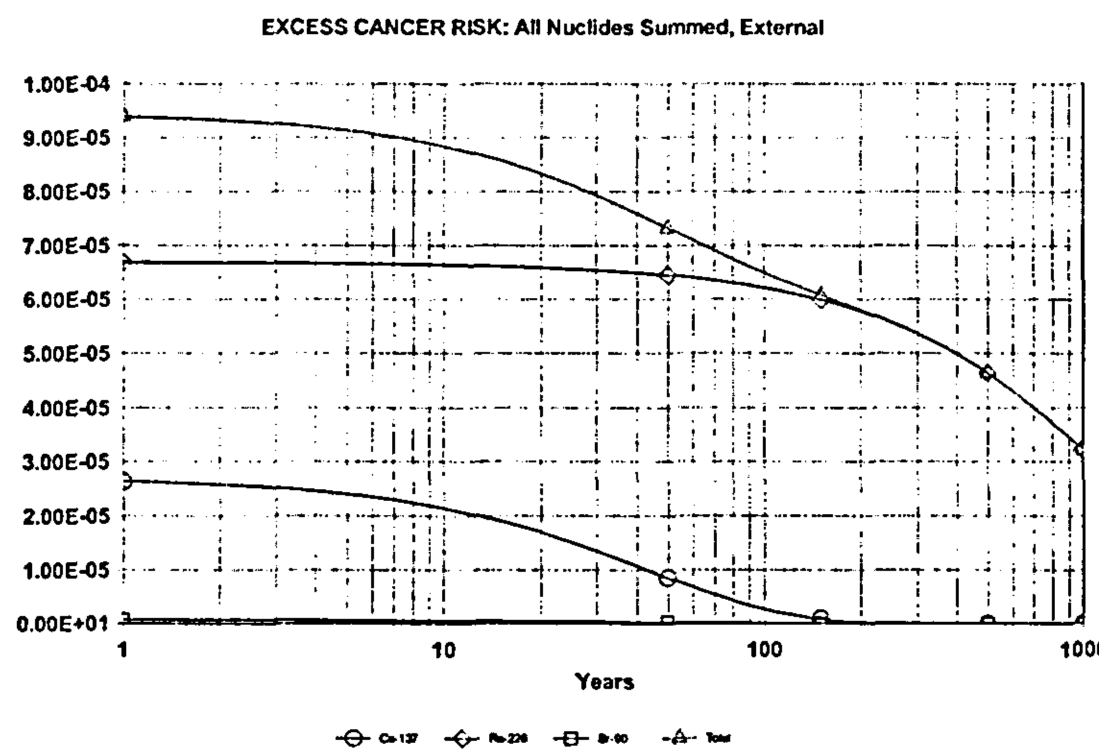
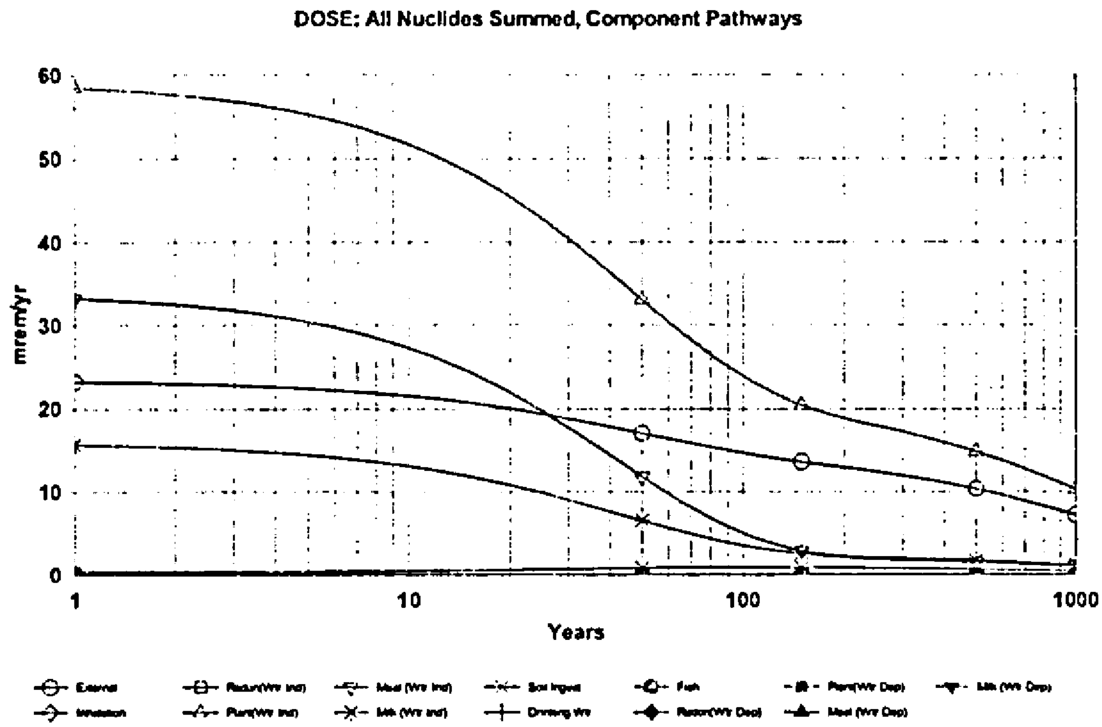


Figure C-24. RESRAD Analysis for 216-B-48 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



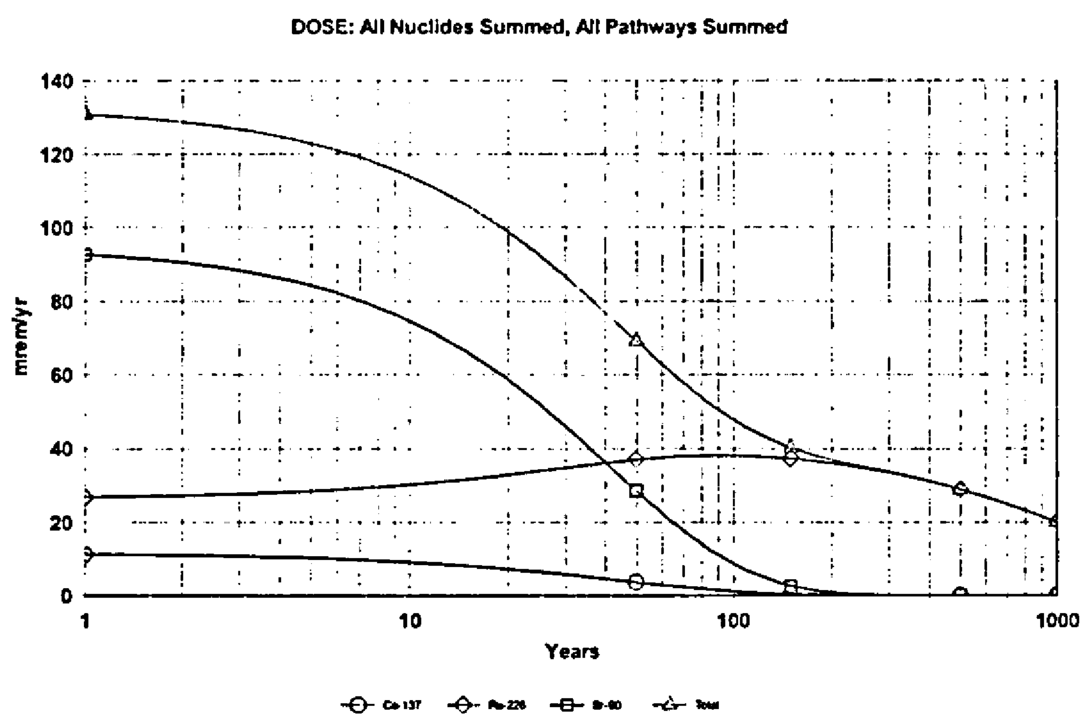
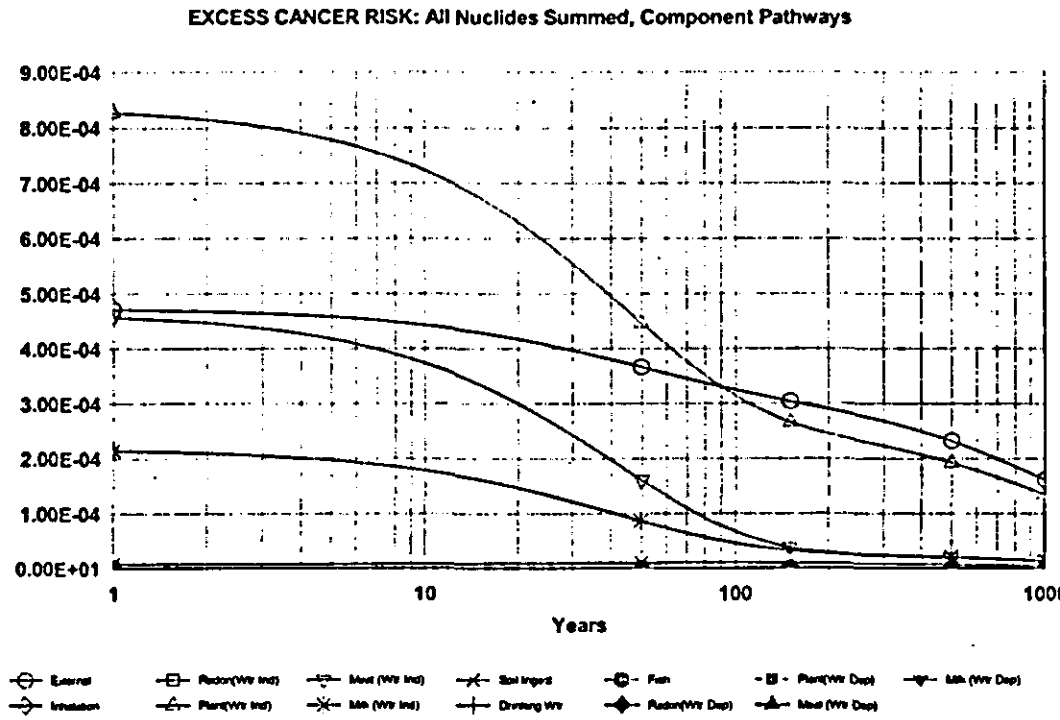


Figure C-25. RESRAD Analysis for 216-B-48 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



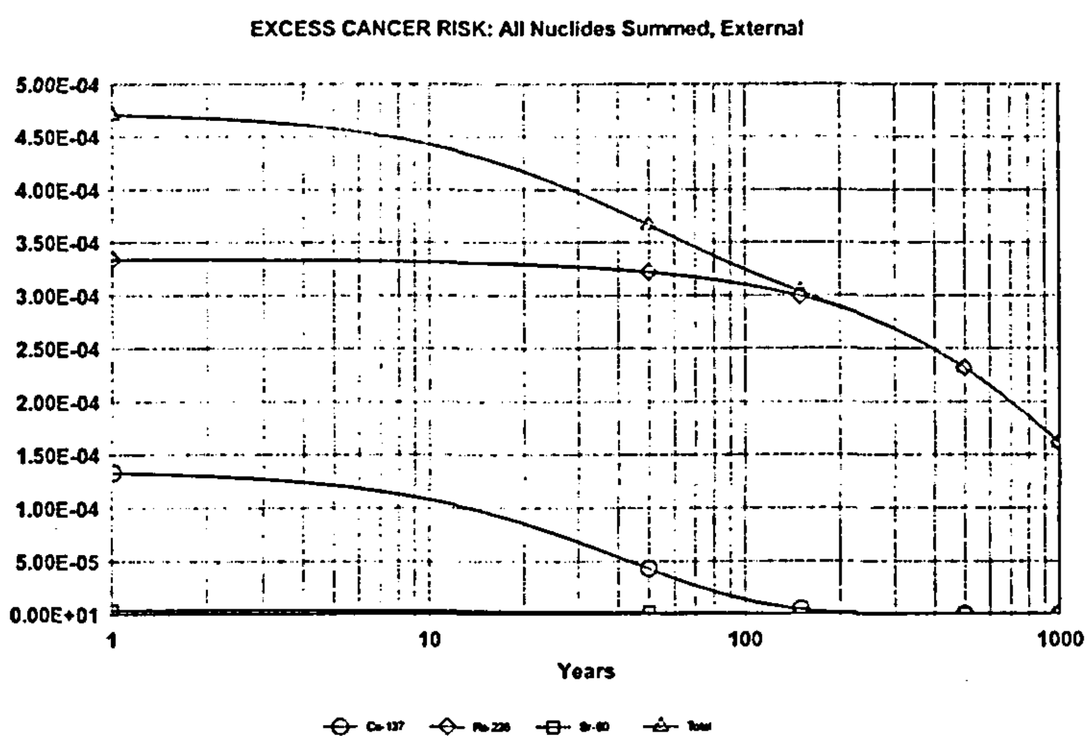
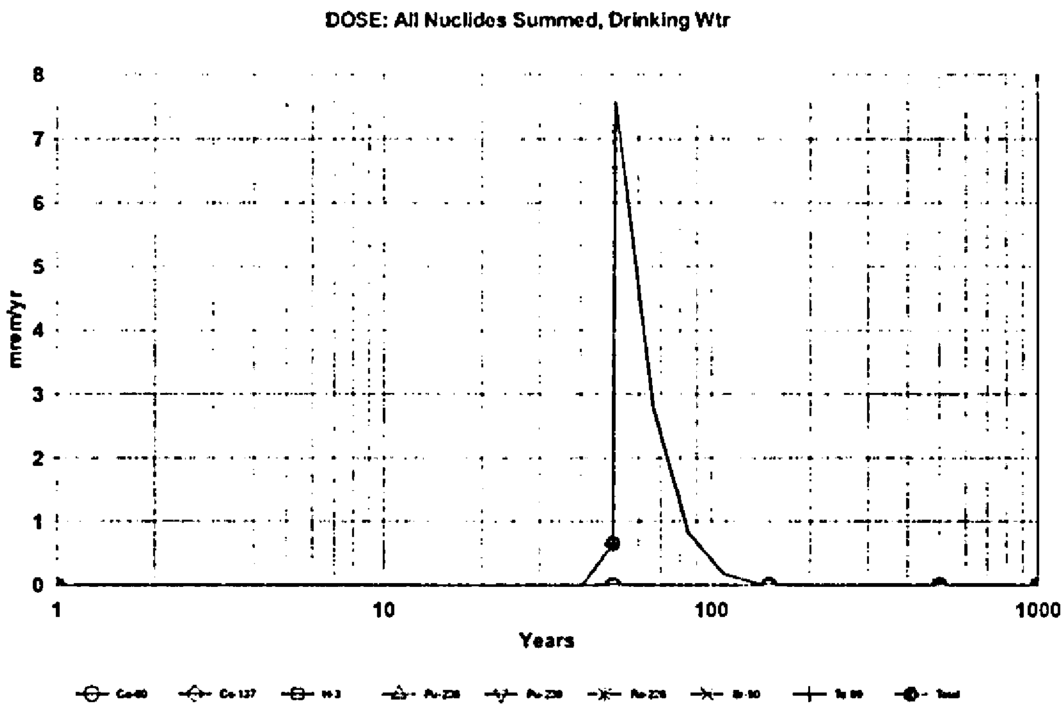


Figure C-26. RESRAD Analysis for 216-B-48 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



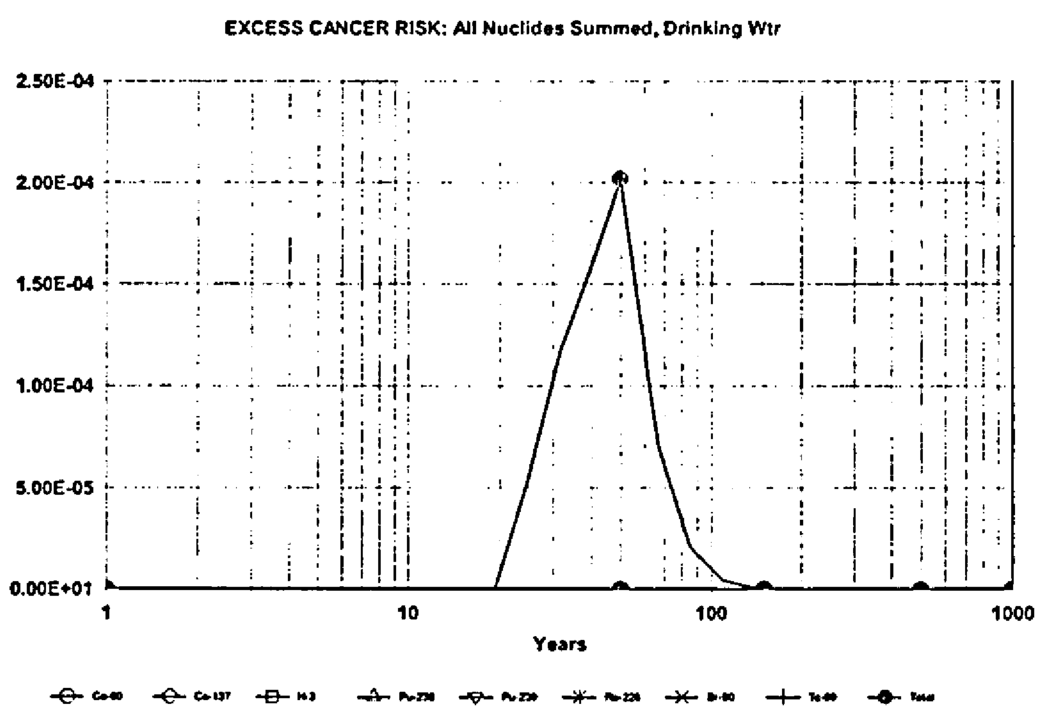
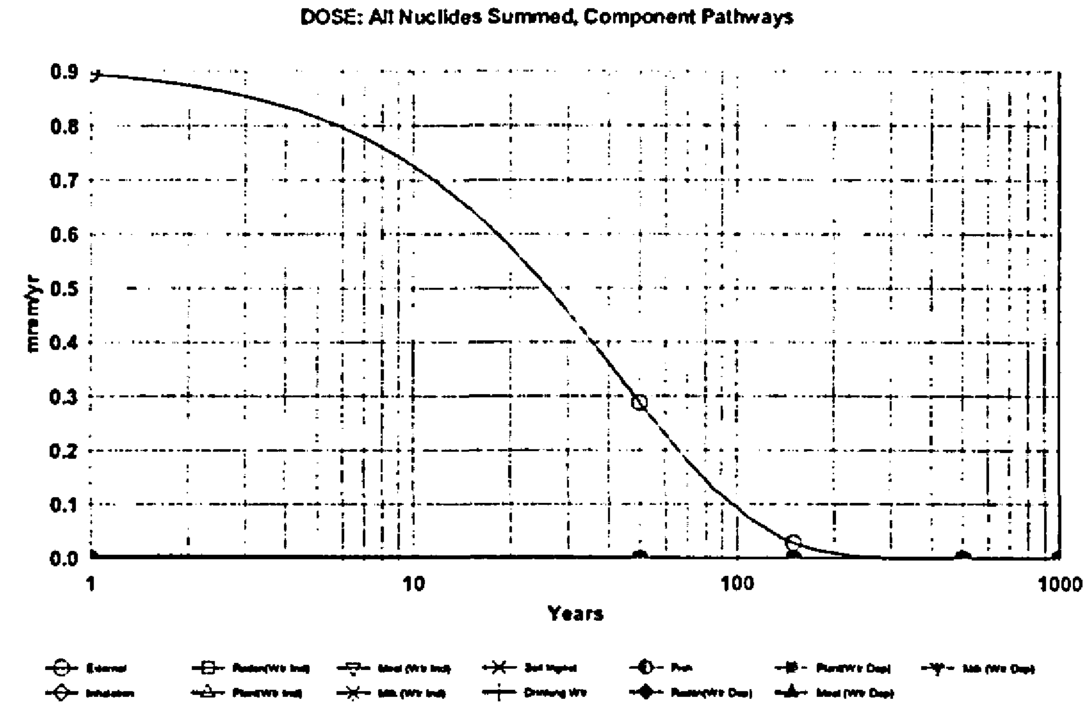


Figure C-27. RESRAD Analysis for 216-B-49 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



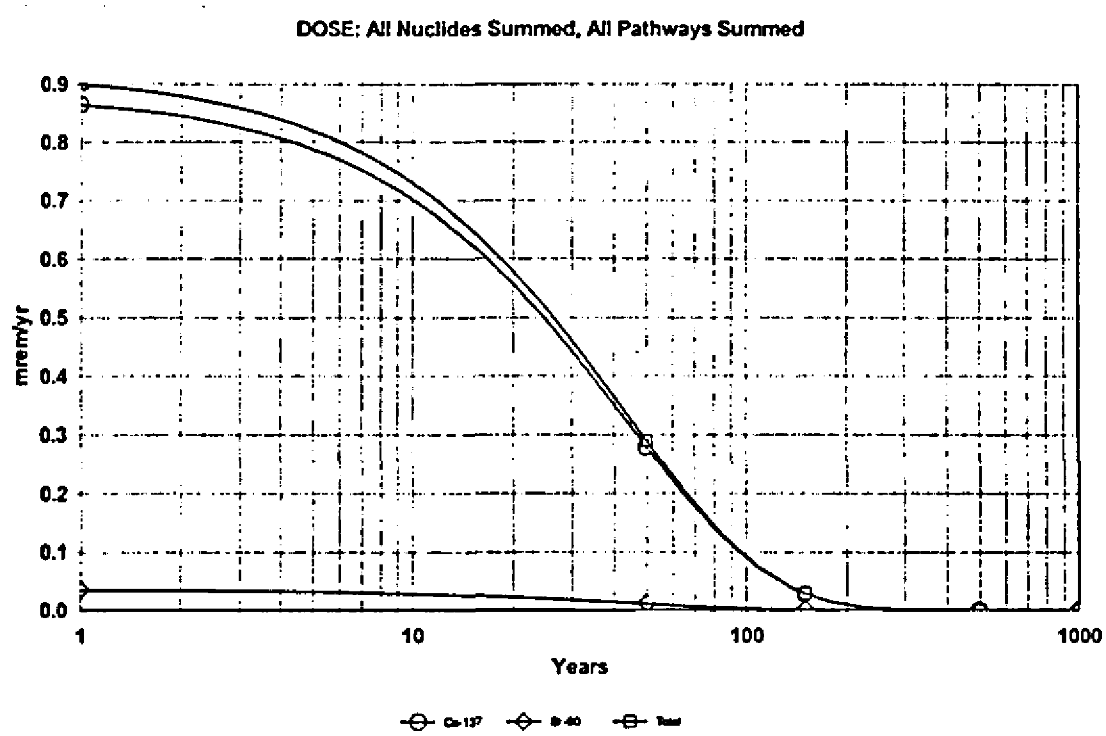
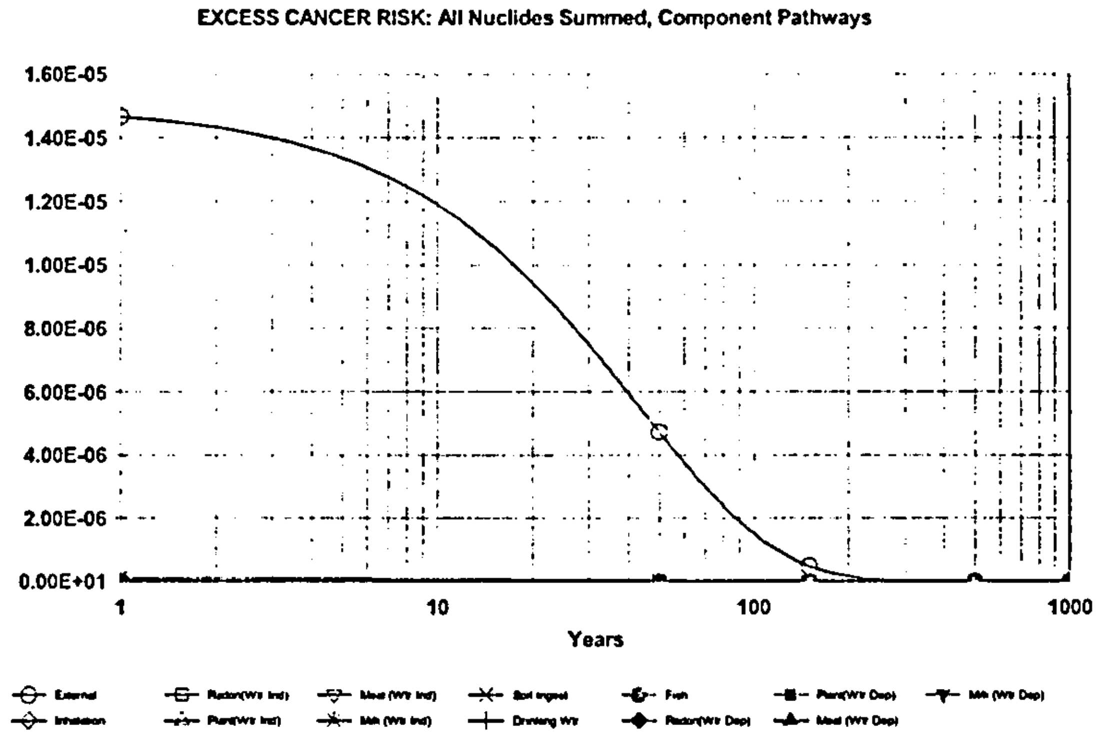


Figure C-28. RESRAD Analysis for 216-B-49 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



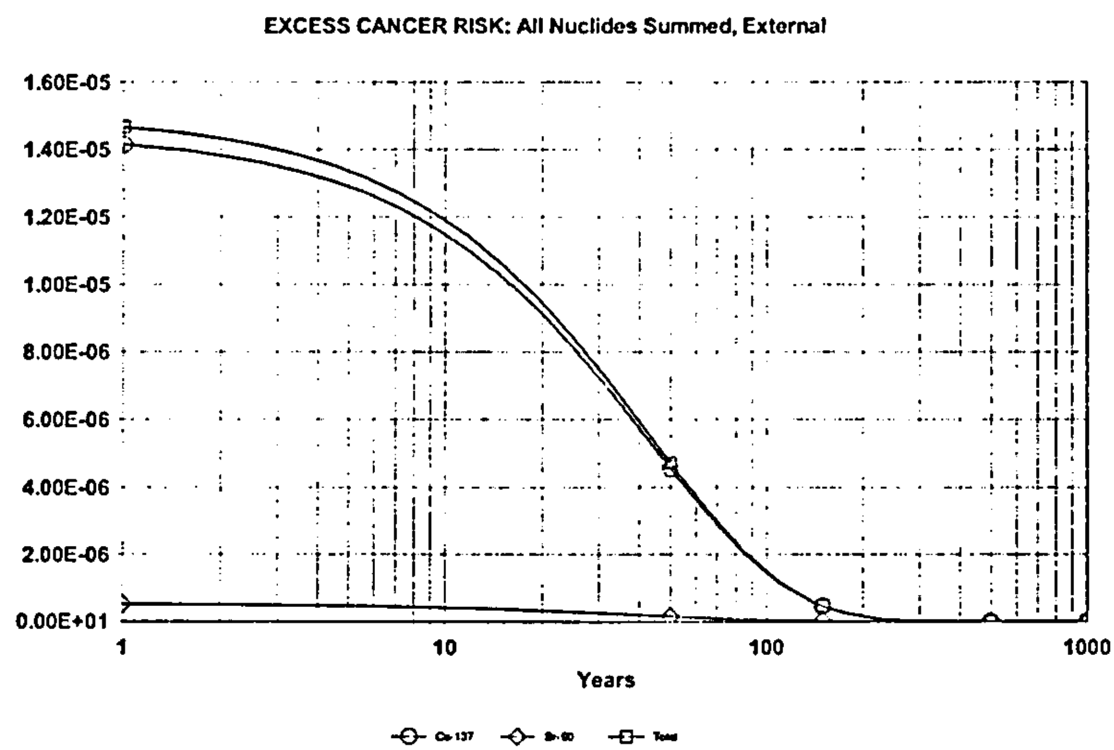
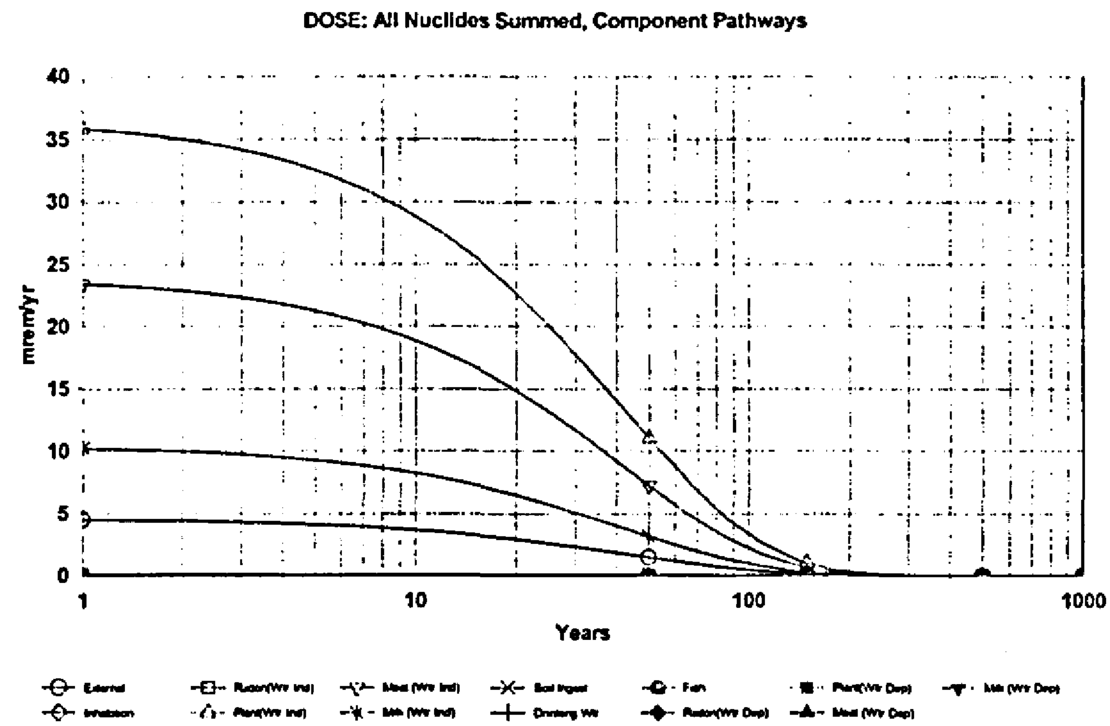


Figure C-29. RESRAD Analysis for 216-B-49 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



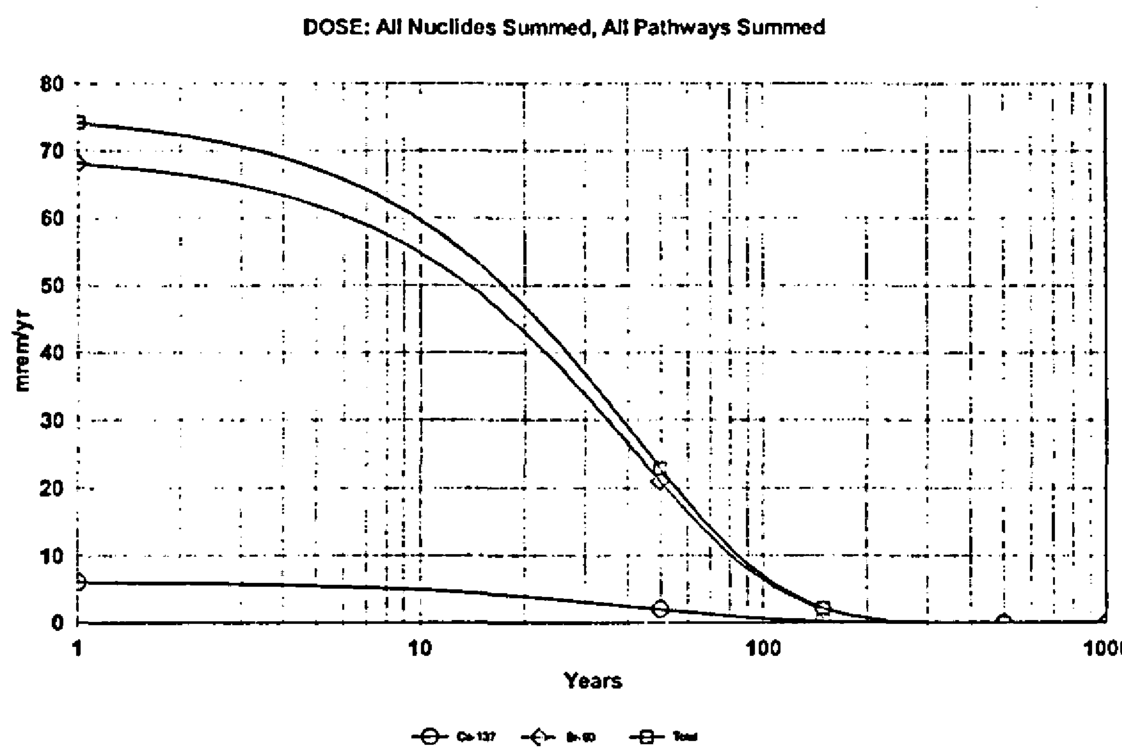
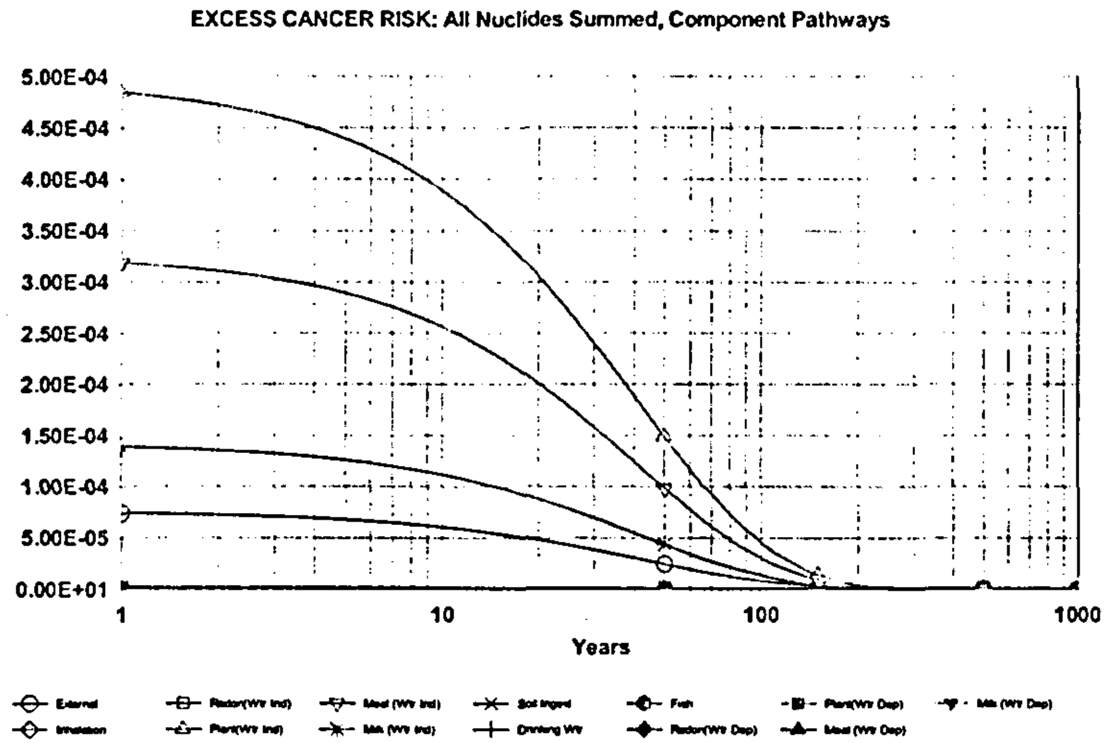


Figure C-30. RESRAD Analysis for 216-B-49 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



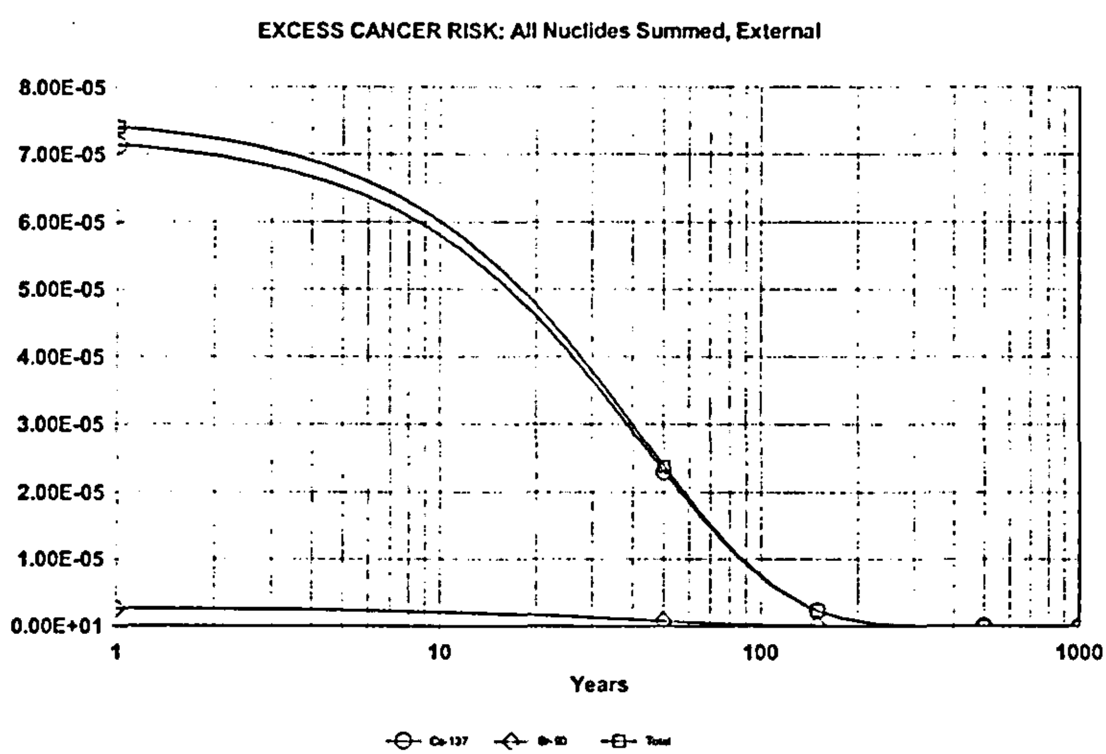
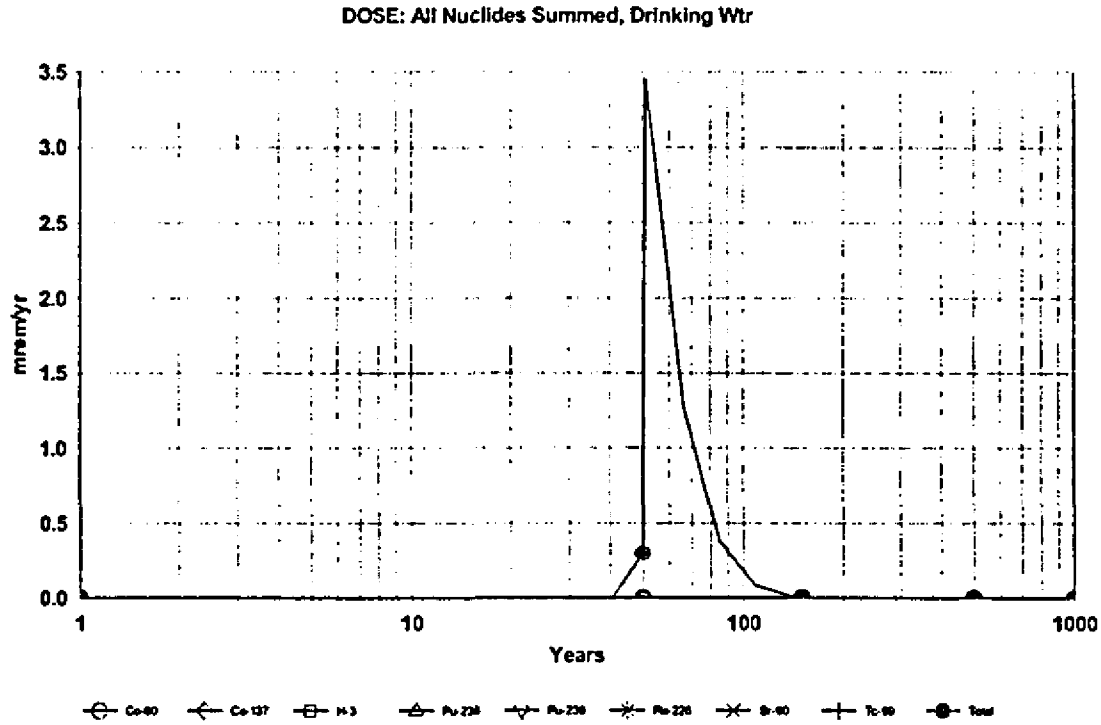


Figure C-31. RESRAD Analysis for 216-B-49 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



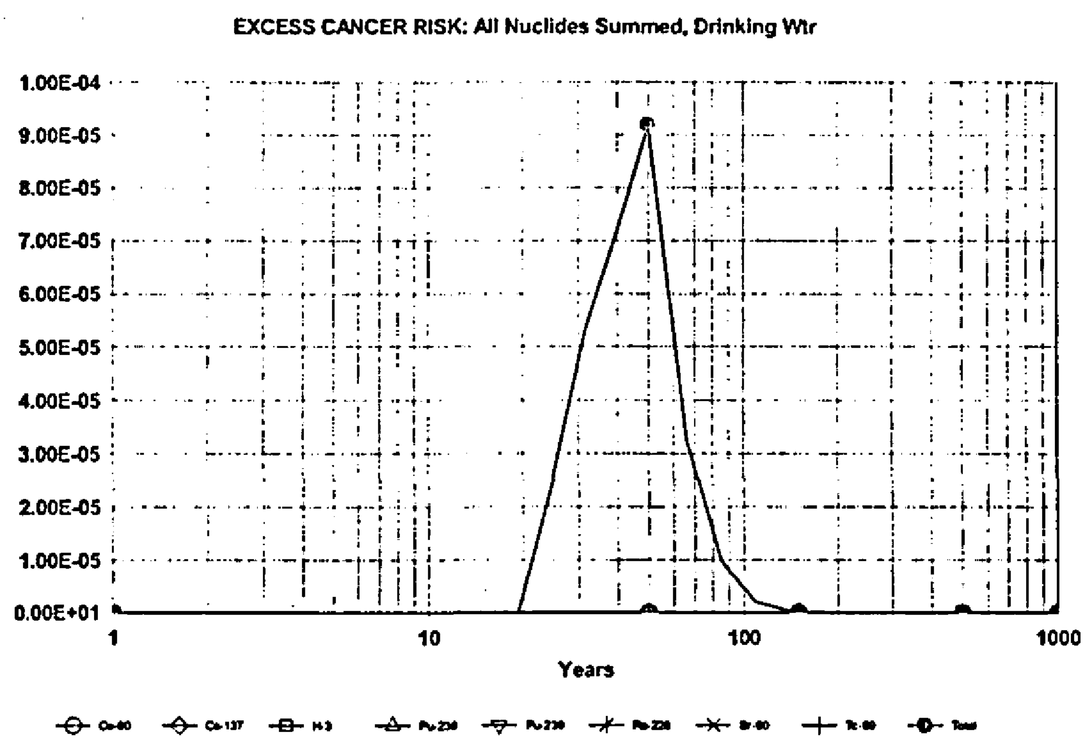
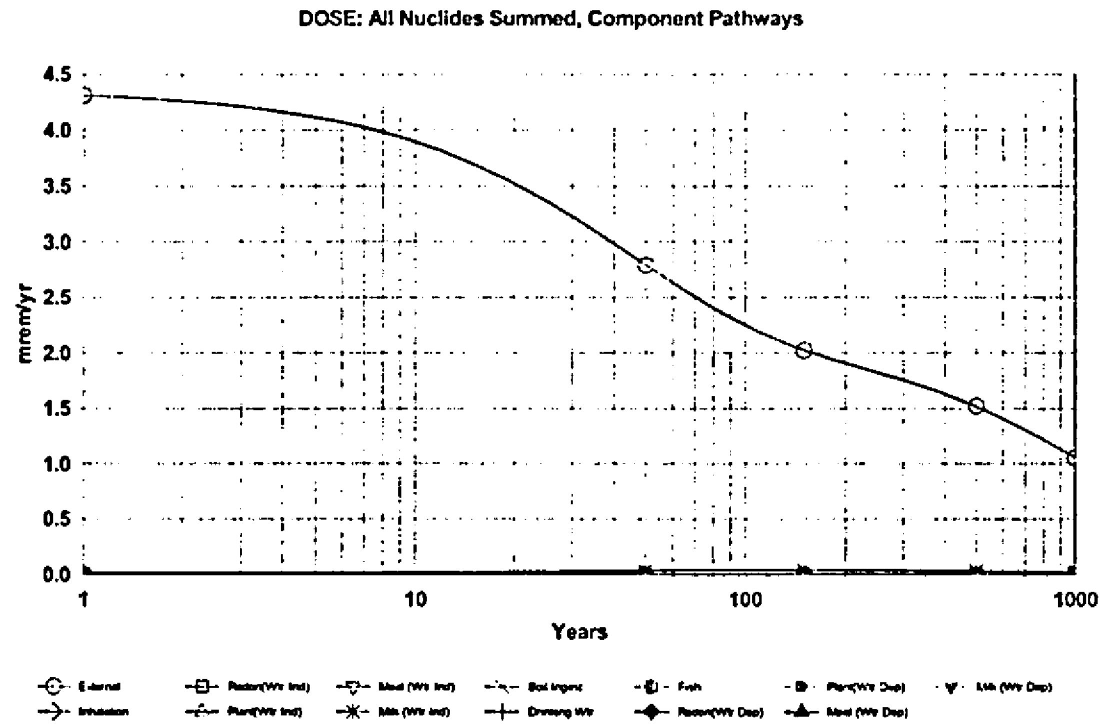


Figure C-32. RESRAD Analysis for 216-B-50 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



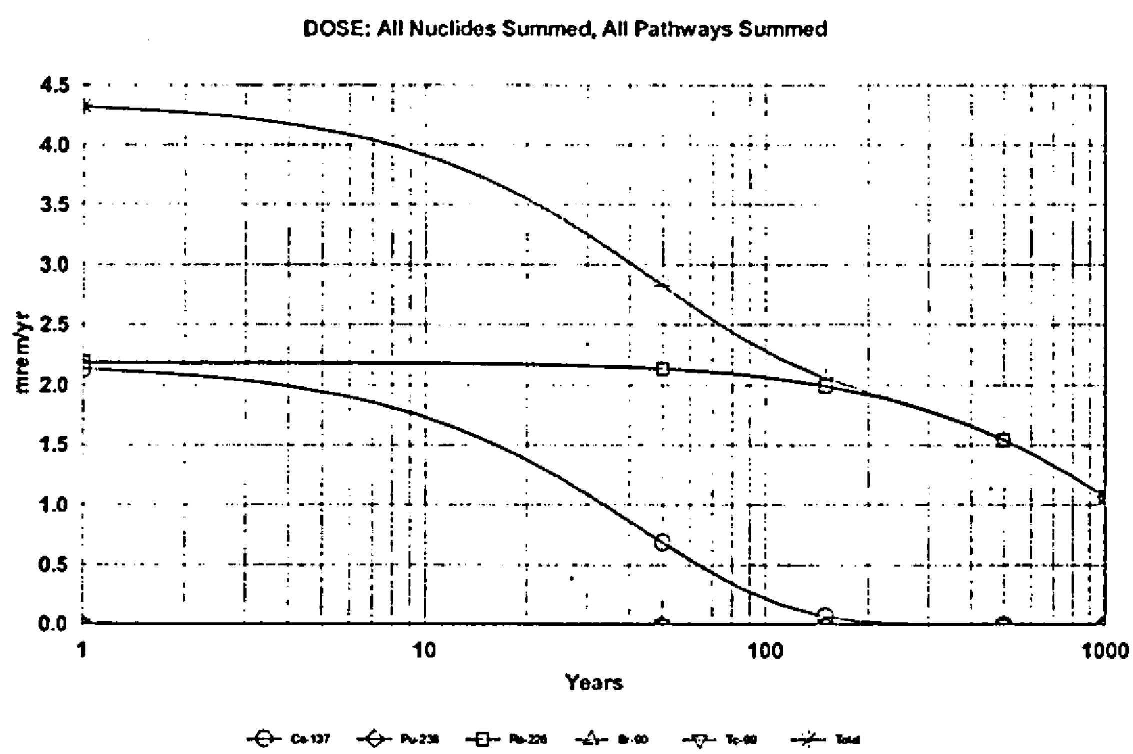
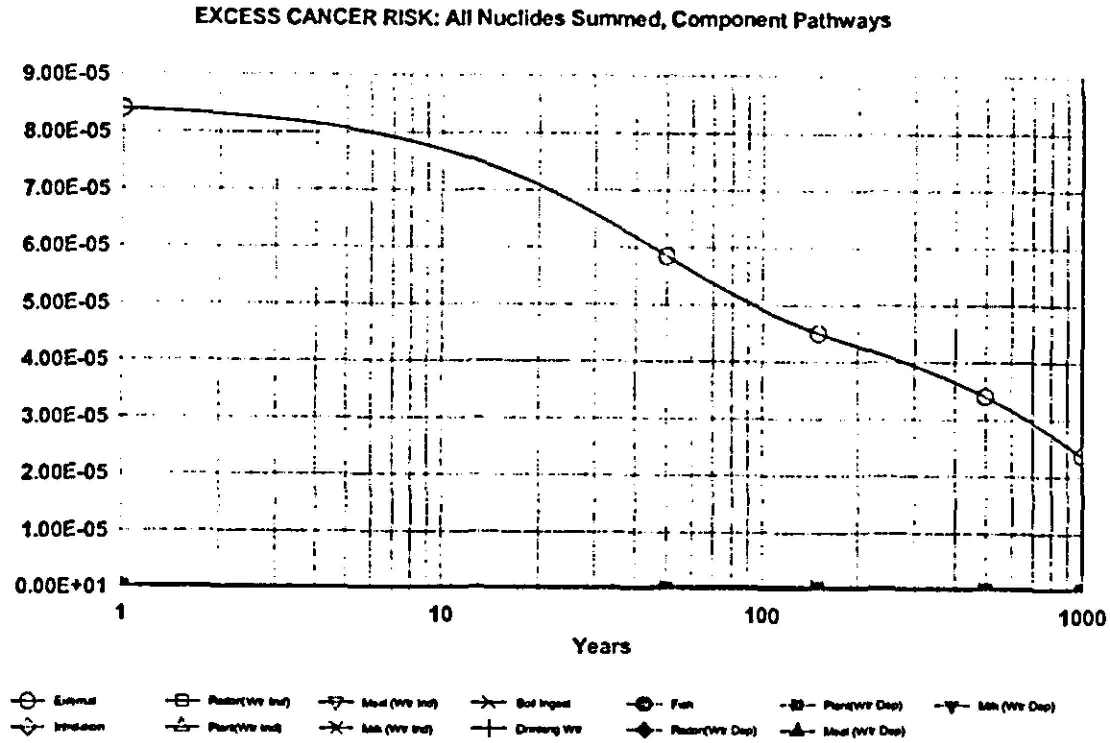


Figure C-33. RESRAD Analysis for 216-B-50 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



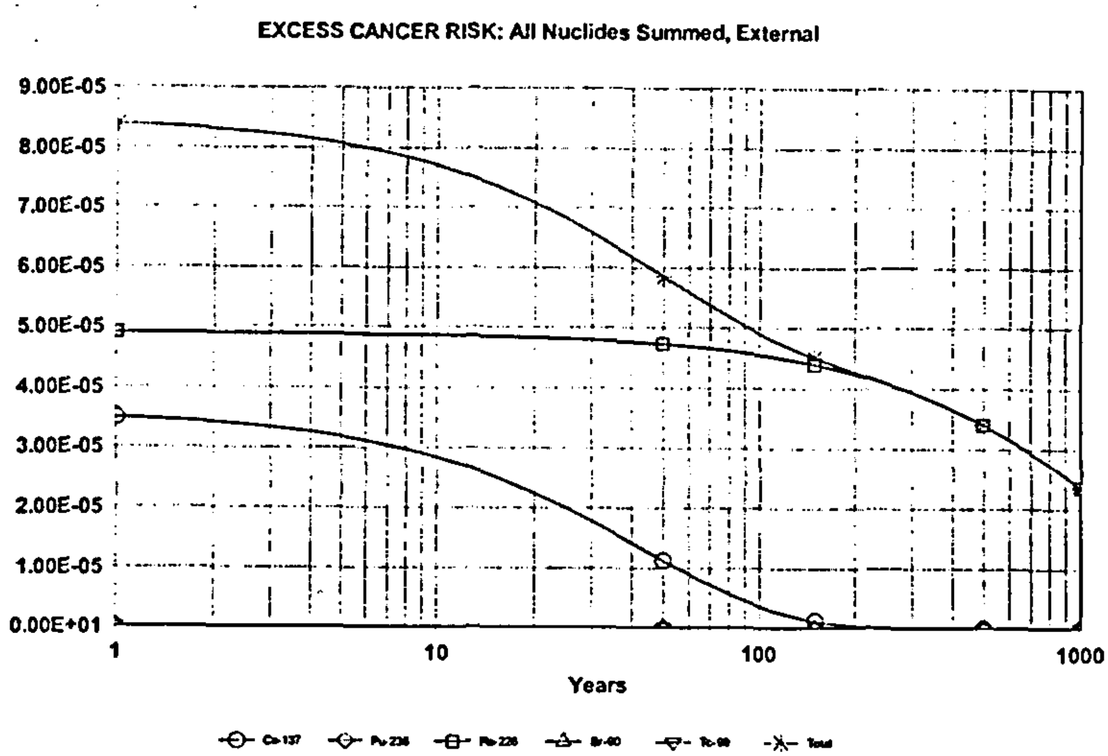
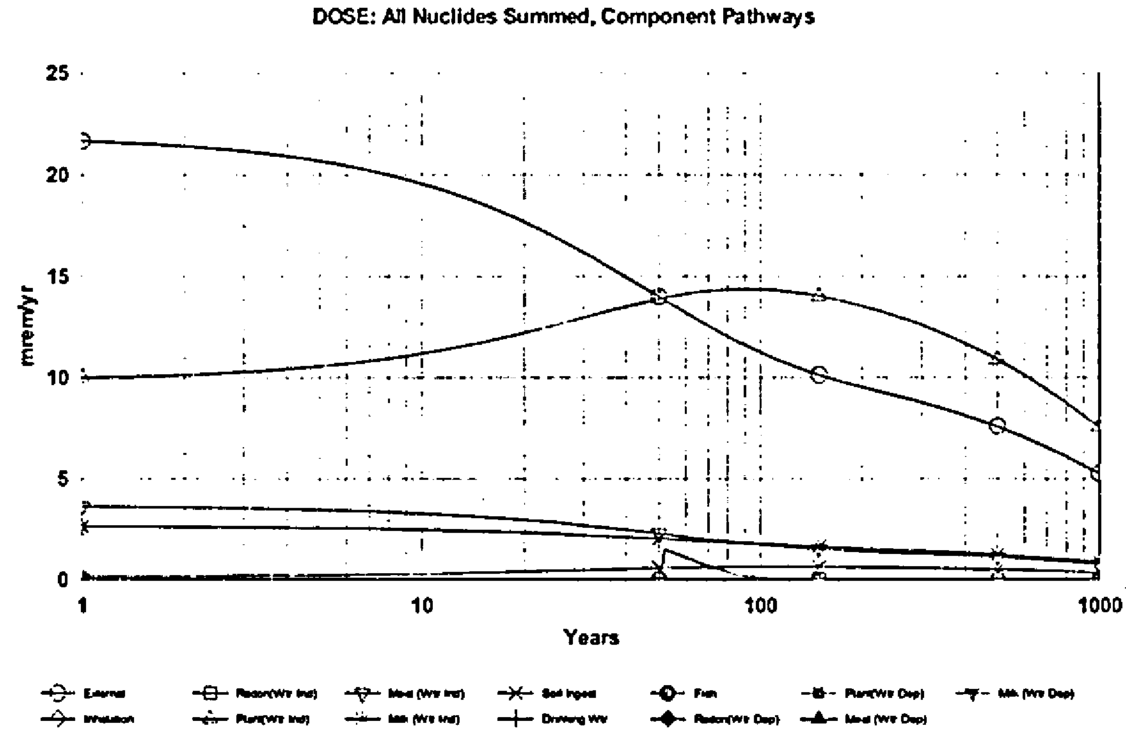


Figure C-34. RESRAD Analysis for 216-B-50 Crib – All Radionuclides, All Pathways Dose Estimate (No Cover, Hypothetical Native American Scenario).



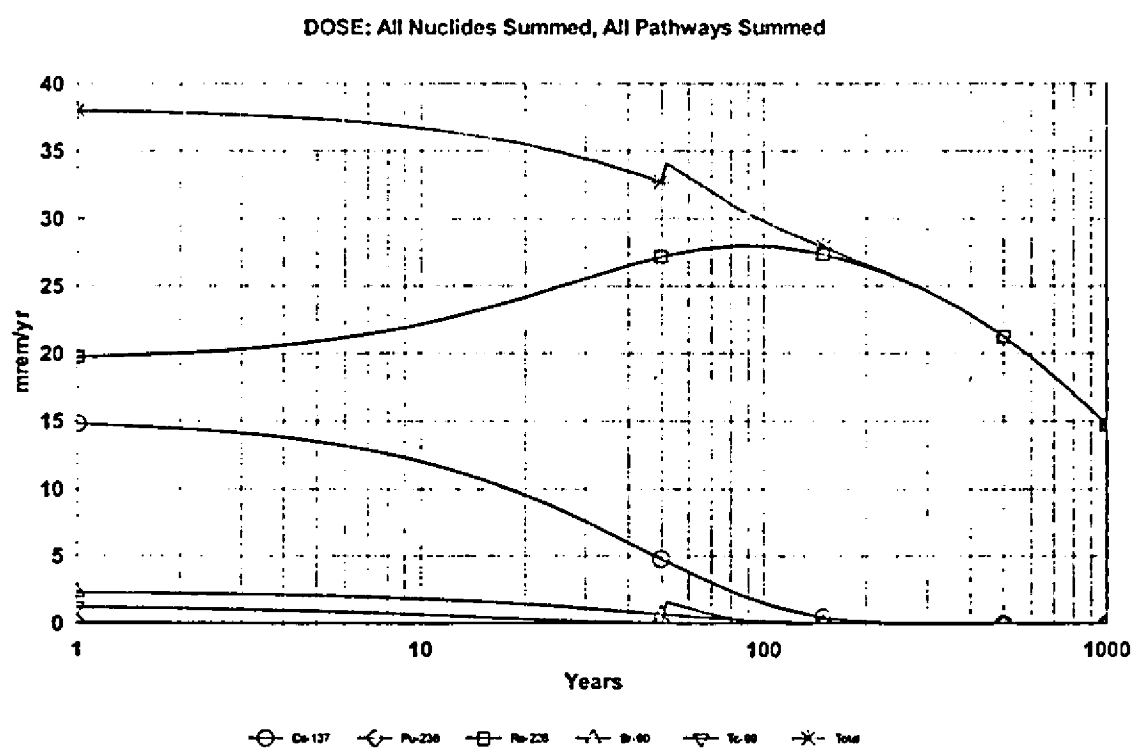
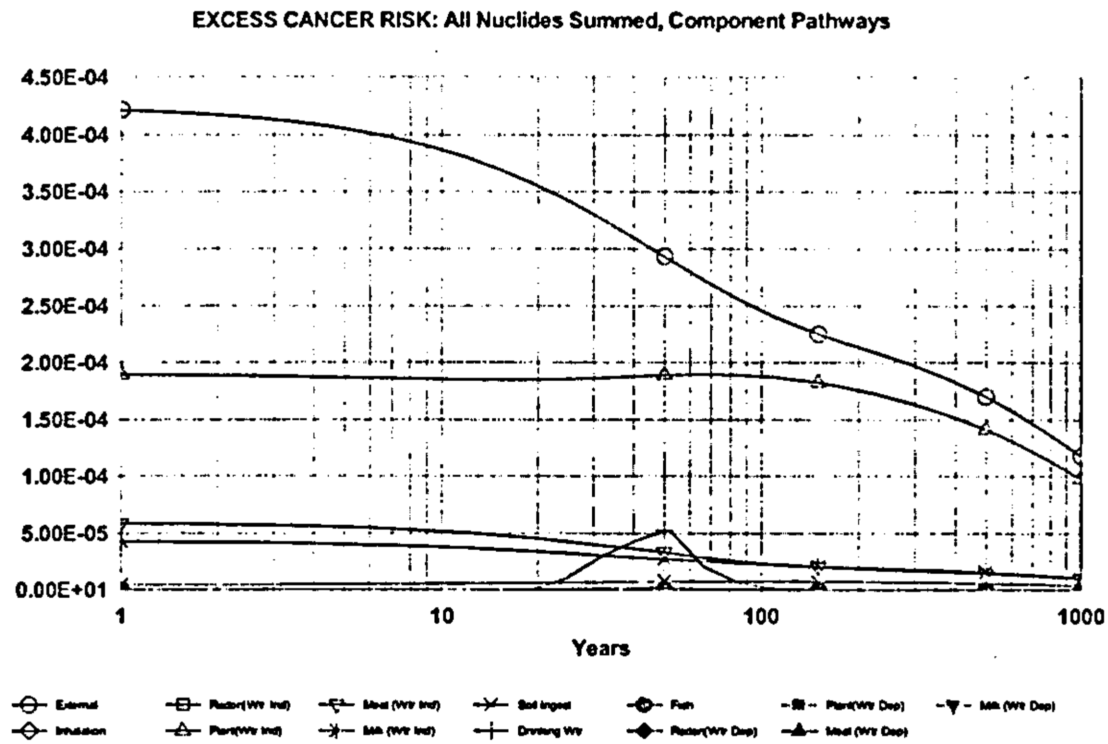


Figure C-35. RESRAD Analysis for 216-B-50 Crib – All Radionuclides, All Pathways Risk Estimate (No Cover, Hypothetical Native American Scenario).



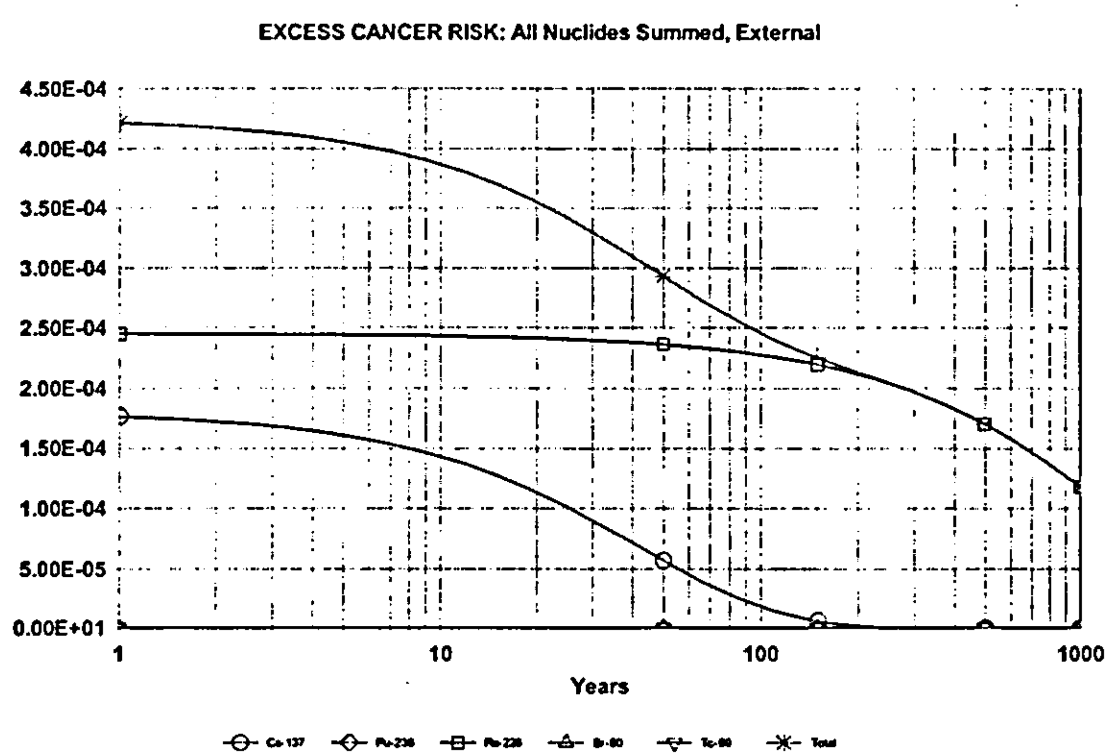
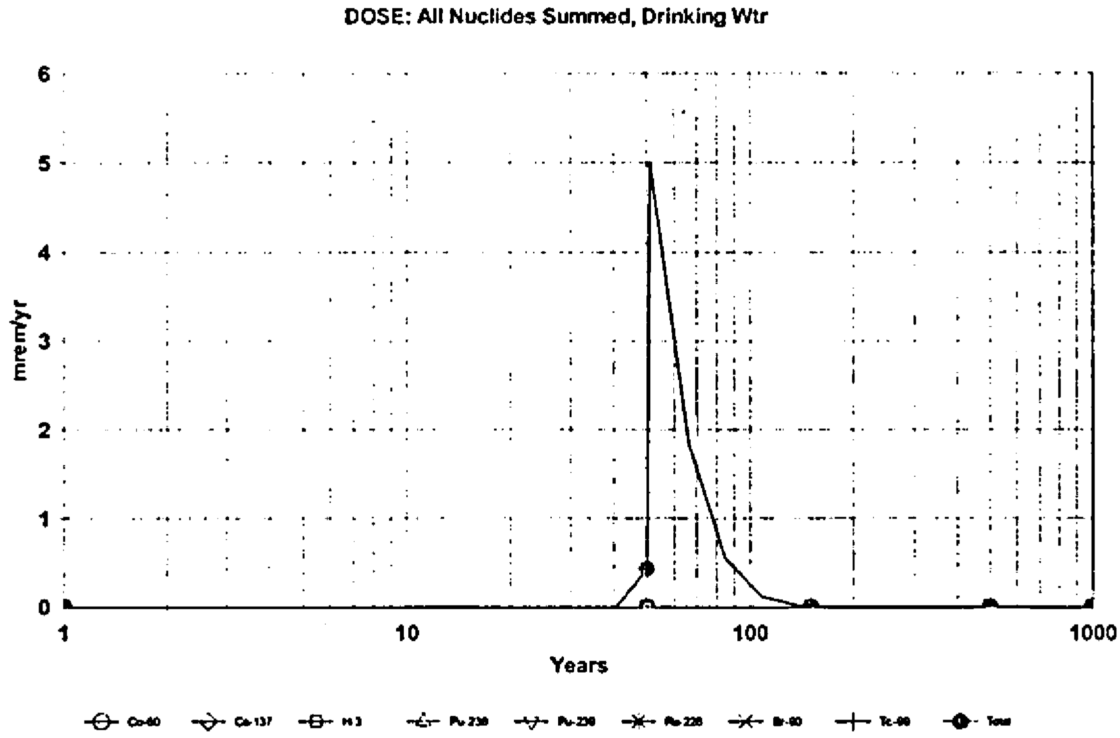


Figure C-36. RESRAD Analysis for 216-B-50 Crib – All Radionuclides, Drinking Water Pathway Dose and Risk Estimate (No Cover).



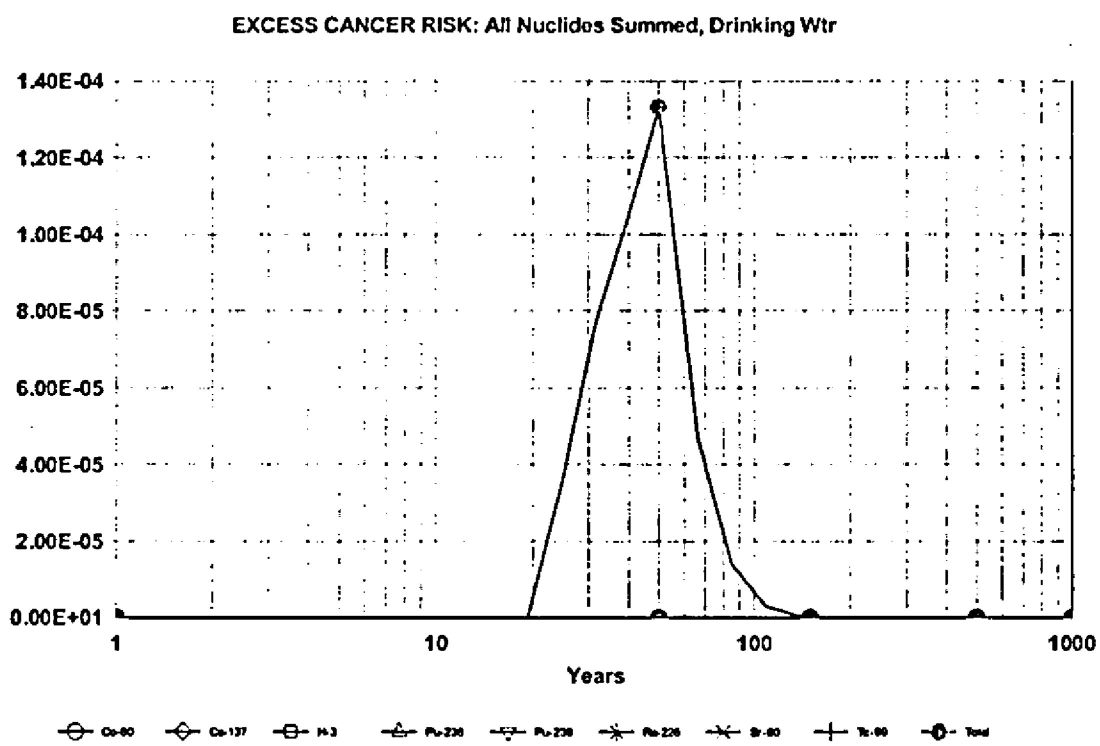


Table C-1. Summary of Samples Used in the Risk Assessment. (3 Pages)

Area of Concern	Station ID	Sample ID	Sample Depth	Date Collected	Comments
216-B-43	299-E33-314	B067Y9	2 to 5	April 23, 1992	Shallow zone
216-B-43	299-E33-296	B015L7	2.5 to 4.5	November 7, 1991	Shallow zone
216-B-43	299-E33-315	B06801	3 to 5.5	April 29, 1992	Shallow zone
216-B-43	299-E33-314	B067Z1	10 to 13	April 23, 1992	Shallow zone
216-B-43	299-E33-315	B06803	10 to 12.5	April 29, 1992	Shallow zone
216-B-43	299-E33-296	B015M3	10.4 to 12.9	November 12, 1999	Shallow zone
216-B-43	299-E33-314	B067Z5	18 to 20.5	April 24, 1992	Deep zone
216-B-43	299-E33-296	B015P9	18.5 to 21	November 21, 1999	Deep zone
216-B-43	299-E33-315	B06809	20 to 22.5	April 29, 1992	Deep zone
216-B-43	299-E33-296	B015P1	26 to 28.5	December 5, 1991	Deep zone
216-B-43	299-E33-314	B067Z3	28 to 30.5	April 24, 1992	Deep zone
216-B-43	299-E33-315	B06811	29 to 31.5	April 30, 1992	Deep zone
216-B-43	299-E33-296	B015Q3	56 to 58.5	January 2, 1992	Deep zone
216-B-43	299-E33-296	B015Q5	56 to 58	January 2, 1992	Deep zone
216-B-43	299-E33-296	B015R1	83.5 to 86	January 6, 1992	Deep zone
216-B-43	299-E33-296	B015R3	108.5 to 111	January 7, 1992	Deep zone
216-B-43	299-E33-296	B015R9	130.5 to 133	January 14, 1992	Deep zone
216-B-43	299-E33-296	B015J6	157.5 to 160	January 20, 1992	Deep zone
216-B-43	299-E33-296	B01S79	188.5 to 191	January 21, 1992	Deep zone
216-B-43	299-E33-296	B01S81	214 to 216.5	January 22, 1992	Deep zone
216-B-43	299-E33-296	B01S87	223 to 227.5	January 23, 1992	Deep zone
216-B-43	299-E33-314	B067Y9	2 to 5	April 23, 1992	Deep zone
216-B-43	299-E33-296	B015L7	2.5 to 4.5	November 7, 1991	Deep zone
216-B-43	299-E33-315	B06801	3 to 5.5	April 29, 1992	Deep zone
216-B-43	299-E33-314	B067Z1	10 to 13	April 23, 1992	Deep zone
216-B-43	299-E33-315	B06803	10-12.5	April 29, 1992	Deep zone
216-B-43	299-E33-296	B015M3	10.4-12.9	November 12, 1999	Deep zone
216-B-44	299-E33-297	B01SG1	3 to 6	March 25, 1992	Shallow zone
216-B-44	299-E33-316	B01SD1	3 to 6	March 18, 1992	Shallow zone
216-B-44	299-E33-316	B01SD4	3 to 6	March 18, 1992	Shallow zone
216-B-44	299-E33-317	B01SJ1	3 to 6	April 3, 1992	Shallow zone
216-B-44	299-E33-297	B01SG5	9 to 11.5	March 25, 1992	Shallow zone
216-B-44	299-E33-316	B01SD5	9 to 12	March 18, 1992	Shallow zone
216-B-44	299-E33-317	B01SJ3	9 to 11.5	April 3, 1992	Shallow zone
216-B-44	299-E33-297	B01SG7	19 to 21.5	March 26, 1992	Deep zone
216-B-44	299-E33-316	B01SD7	21.5 to 24	March 19, 1992	Deep zone
216-B-44	299-E33-317	B01SB4	22 to 24.5	April 8, 1992	Deep zone
216-B-44	299-E33-297	B01SG9	29 to 31.5	March 30, 1992	Deep zone
216-B-44	299-E33-316	B01SD9	29 to 31.5	March 19, 1992	Deep zone
216-B-44	299-E33-317	B01SC8	29 to 31.5	April 8, 1992	Deep zone
216-B-44	299-E33-297	B01SG1	3 to 6	March 25, 1992	Deep zone
216-B-44	299-E33-316	B01SD1	3 to 6	March 18, 1992	Deep zone
216-B-44	299-E33-316	B01SD4	3 to 6	March 18, 1992	Deep zone
216-B-44	299-E33-317	B01SJ1	3 to 6	April 3, 1992	Deep zone
216-B-44	299-E33-297	B01SG5	9 to 11.5	March 25, 1992	Deep zone
216-B-44	299-E33-316	B01SD5	9 to 12	March 18, 1992	Deep zone
216-B-44	299-E33-317	B01SJ3	9 to 11.5	April 3, 1992	Deep zone
216-B-45	299-E33-298	B01S91	2 to 5	February 28, 1992	Shallow zone
216-B-45	299-E33-318	B015P2	3 to 5.5	January 20, 1992	Shallow zone
216-B-45	299-E33-319	B01SB5	3 to 6	March 10, 1992	Shallow zone

Table C-1. Summary of Samples Used in the Risk Assessment. (3 Pages)

Area of Concern	Station ID	Sample ID	Sample Depth	Date Collected	Comments
216-B-45	299-E33-319	B01SB7	3 to 6	March 10, 1992	Shallow zone
216-B-45	299-E33-298	B01S93	10 to 13	February 28, 1992	Shallow zone
216-B-45	299-E33-318	B015Q0	10 to 12.5	January 20, 1992	Shallow zone
216-B-45	299-E33-319	B01SB9	10 to 13	March 10, 1992	Shallow zone
216-B-45	299-E33-298	B01S97	17 to 19.5	March 2, 1992	Deep zone
216-B-45	299-E33-318	B01S75	17 to 19	January 22, 1992	Deep zone
216-B-45	299-E33-319	B01SB2	17 to 20	March 11, 1992	Deep zone
216-B-45	299-E33-298	B01S99	20 to 20.5	March 3, 1992	Deep zone
216-B-45	299-E33-298	B01SB3	27 to 29.5	March 5, 1992	Deep zone
216-B-45	299-E33-318	B01S77	27 to 28.5	January 27, 1992	Deep zone
216-B-45	299-E33-319	B01SC5	27 to 29.5	March 11, 1992	Deep zone
216-B-45	299-E33-298	B01S91	2 to 5	February 28, 1992	Deep zone
216-B-45	299-E33-318	B015P2	3 to 5.5	January 20, 1992	Deep zone
216-B-45	299-E33-319	B01SB5	3 to 6	March 10, 1992	Deep zone
216-B-45	299-E33-319	B01SB7	3 to 6	March 10, 1992	Deep zone
216-B-45	299-E33-298	B01S93	10 to 13	February 28, 1992	Deep zone
216-B-45	299-E33-318	B015Q0	10 to 12.5	January 20, 1992	Deep zone
216-B-45	299-E33-319	B01SB9	10 to 13	March 10, 1992	Deep zone
216-B-47	299-E33-320	B01SD8	2.5 to 5	April 14, 1992	Shallow zone
216-B-47	299-E33-321	B06817	3 to 5.5	May 6, 1992	Shallow zone
216-B-47	299-E33-300	B067Z7	3.2 to 5.7	April 27, 1992	Shallow zone
216-B-47	299-E33-320	B01SG4	11.5 to 14	April 15, 1992	Shallow zone
216-B-47	299-E33-321	B06819	12.5 to 15	May 7, 1992	Shallow zone
216-B-47	299-E33-300	B067Z9	13.5 to 16	April 28, 1992	Shallow zone
216-B-47	299-E33-300	B06800	13.5 to 16	April 28, 1992	Shallow zone
216-B-47	299-E33-321	B06825	21 to 23.5	May 11, 1992	Deep zone
216-B-47	299-E33-300	B06813	22 to 24.5	May 1, 1992	Deep zone
216-B-47	299-E33-320	B067Y5	23 to 25.5	April 16, 1992	Deep zone
216-B-47	299-E33-321	B06827	31 to 33.5	May 12, 1992	Deep zone
216-B-47	299-E33-300	B06815	32 to 34.5	May 4, 1992	Deep zone
216-B-47	299-E33-320	B067Y7	32.5 to 35	April 22, 1992	Deep zone
216-B-47	299-E33-320	B01SD8	2.5 to 5	April 14, 1992	Deep zone
216-B-47	299-E33-321	B06817	3 to 5.5	May 6, 1992	Deep zone
216-B-47	299-E33-300	B067Z7	3.2 to 5.7	April 27, 1992	Deep zone
216-B-47	299-E33-320	B01SG4	11.5 to 14	April 15, 1992	Deep zone
216-B-47	299-E33-321	B06819	12.5 to 15	May 7, 1992	Deep zone
216-B-47	299-E33-300	B067Z9	13.5 to 16	April 28, 1992	Deep zone
216-B-47	299-E33-300	B06800	13.5 to 16	April 28, 1992	Deep zone
216-B-48	299-E33-301	B01SF1	2.5 to 5	March 20, 1992	Shallow zone
216-B-48	299-E33-322	B01SC1	3 to 5.5	March 11, 1992	Shallow zone
216-B-48	299-E33-323	B01SH1	3 to 5.5	March 31, 1992	Shallow zone
216-B-48	299-E33-322	B01SC3	9 to 11.5	March 12, 1992	Shallow zone
216-B-48	299-E33-301	B01SF5	10 to 12.5	March 20, 1992	Shallow zone
216-B-48	299-E33-323	B01SH5	10 to 12.5	March 31, 1992	Shallow zone
216-B-48	299-E33-322	B01SC7	17.5 to 20	March 13, 1992	Deep zone
216-B-48	299-E33-323	B01SH7	19 to 21.5	April 1, 1992	Deep zone
216-B-48	299-E33-301	B01SF7	19.5 to 22	March 23, 1992	Deep zone
216-B-48	299-E33-322	B01SC9	28 to 30.5	March 16, 1992	Deep zone
216-B-48	299-E33-301	B01SF9	29 to 32	March 25, 1992	Deep zone
216-B-48	299-E33-323	B01SH9	29 to 31.5	April 2, 1992	Deep zone

Table C-1. Summary of Samples Used in the Risk Assessment. (3 Pages)

Area of Concern	Station ID	Sample ID	Sample Depth	Date Collected	Comments
216-B-48	299-E33-323	B01SH1	3 to 5.5	March 31, 1992	Deep zone
216-B-48	299-E33-322	B01SC3	9 to 11.5	March 12, 1992	Deep zone
216-B-48	299-E33-301	B01SF5	10 to 12.5	March 20, 1992	Deep zone
216-B-48	299-E33-323	B01SH5	10 to 12.5	March 31, 1992	Deep zone
216-B-49	299-E33-313	B01S83	2 to 4.5	January 23, 1992	Shallow zone
216-B-49	299-E33-312	B015L9	2.5 to 5	November 8, 1991	Shallow zone
216-B-49	299-E33-302	B00X67	3 to 5.5	July 25, 1991	Shallow zone
216-B-49	299-E33-302	B00X69	8.5 to 11	July 25, 1991	Shallow zone
216-B-49	299-E33-313	B01S85	9 to 11.5	January 24, 1992	Shallow zone
216-B-49	299-E33-312	B015M1	10 to 12.5	November 11, 1999	Shallow zone
216-B-49	299-E33-313	B01S89	16.5 to 19	January 27, 1992	Deep zone
216-B-49	299-E33-302	B00X75	17 to 20	August 6, 1991	Deep zone
216-B-49	299-E33-312	B015M9	17 to 19.5	November 14, 1999	Deep zone
216-B-49	299-E33-302	B00XB7	25 to 27.5	September 6, 1991	Deep zone
216-B-49	299-E33-312	B015M7	27 to 29.5	November 20, 1999	Deep zone
216-B-49	299-E33-313	B01S95	27 to 29.5	March 2, 1992	Deep zone
216-B-49	299-E33-302	B00X76	46.5 to 49	September 19, 1991	Deep zone
216-B-49	299-E33-302	B00XD5	75 to 77.5	September 25, 1991	Deep zone
216-B-49	299-E33-302	B015G3	104.5 to 107	September 30, 1991	Deep zone
216-B-49	299-E33-302	B015H5	135 to 137.5	October 9, 1991	Deep zone
216-B-49	299-E33-302	B015K1	162 to 164.5	October 22, 1999	Deep zone
216-B-49	299-E33-302	B015K7	190.5 to 193	October 25, 1999	Deep zone
216-B-49	299-E33-302	B015K9	217 to 219.5	November 4, 1991	Deep zone
216-B-49	299-E33-313	B01S83	2 to 4.5	January 23, 1992	Deep zone
216-B-49	299-E33-312	B015L9	2.5 to 5	November 8, 1991	Deep zone
216-B-49	299-E33-302	B00X67	3 to 5.5	July 25, 1991	Deep zone
216-B-49	299-E33-302	B00X69	8.5 to 11	July 25, 1991	Deep zone
216-B-49	299-E33-313	B01S85	9 to 11.5	January 24, 1992	Deep zone
216-B-49	299-E33-312	B015M1	10 to 12.5	November 11, 1999	Deep zone
216-B-50	299-E33-303	B015G5	3.5 to 6	October 2, 1991	Shallow zone
216-B-50	299-E33-309	B015H7	3.5 to 6	October 17, 1999	Shallow zone
216-B-50	299-E33-308	B015L1	4.6 to 7	November 4, 1991	Shallow zone
216-B-50	299-E33-308	B015L3	9.8 to 11.8	November 4, 1991	Shallow zone
216-B-50	299-E33-309	B015J9	11 to 15	October 17, 1999	Shallow zone
216-B-50	299-E33-303	B015G7	12 to 16	October 2, 1991	Shallow zone
216-B-50	299-E33-303	B015G9	15.5 to 17.5	October 4, 1991	Deep zone
216-B-50	299-E33-308	B015L5	15.7 to 17.8	November 6, 1991	Deep zone
216-B-50	299-E33-309	B015K3	19 to 20.5	October 22, 1999	Deep zone
216-B-50	299-E33-308	B015M5	26.5 to 29	November 12, 1999	Deep zone
216-B-50	299-E33-303	B015H3	28 to 30.5	October 9, 1991	Deep zone
216-B-50	299-E33-309	B015K5	28 to 30.5	October 23, 1999	Deep zone
216-B-50	299-E33-309	B015H7	3.5 to 6	October 17, 1999	Deep zone
216-B-50	299-E33-308	B015L1	4.6 to 7	November 4, 1991	Deep zone
216-B-50	299-E33-308	B015L3	9.8 to 11.8	November 4, 1991	Deep zone
216-B-50	299-E33-309	B015J9	11 to 15	October 17, 1999	Deep zone
216-B-50	299-E33-303	B015G7	12 to 16	October 2, 1991	Deep zone

Table C-2. Summary of Statistics for Shallow Zone Soils from 216-B-43 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	3	3	100%	--	--	3,330	4,530	3,980	5,601	5,002	4,530	Max detect
METAL	Arsenic	mg/kg	5	5	100%	--	--	1.6	2.3	1.9	2.2	2.2	2.2	Lognormal
METAL	Barium	mg/kg	5	5	100%	--	--	53	101	67	92	86	92	Lognormal
METAL	Beryllium	mg/kg	5	3	60%	0.31	0.36	0.35	0.42	0.31	0.63	0.43	0.42	Max detect
METAL	Calcium	mg/kg	5	5	100%	--	--	6,220	11,400	7,936	10,335	9,865	10,335	Lognormal
METAL	Chromium	mg/kg	5	4	80%	4.9	4.9	5.8	7.1	5.8	11	7.6	7.1	Max detect
METAL	Cobalt	mg/kg	5	3	60%	8.2	8.7	6.2	8.8	6.3	9.7	8.2	8.2	Normal
METAL	Copper	mg/kg	5	5	100%	--	--	9.5	16	12	15	14	15	Lognormal
METAL	Iron	mg/kg	5	5	100%	--	--	10,300	15,900	12,640	15,239	14,761	15,239	Lognormal
METAL	Lead	mg/kg	4	4	100%	--	--	3.4	4.9	4.1	5.6	5.0	4.9	Max detect
METAL	Magnesium	mg/kg	5	5	100%	--	--	2,750	3,800	3,250	3,711	3,641	3,641	Normal
METAL	Manganese	mg/kg	5	5	100%	--	--	219	264	240	261	259	259	Normal
METAL	Nickel	mg/kg	5	5	100%	--	--	5.7	8.3	7.2	8.3	8.1	8.1	Normal
METAL	Potassium	mg/kg	5	4	80%	995	995	952	1,200	949	1,503	1,208	1,200	Max detect
METAL	Silver	mg/kg	5	1	20%	1.6	2.1	2.5	2.5	1.2	2.4	1.9	2.4	Lognormal
METAL	Sodium	mg/kg	5	5	100%	--	--	147	441	262	540	385	441	Max detect
METAL	Vanadium	mg/kg	5	4	80%	23	23	18	29	21	33	27	27	Normal
METAL	Zinc	mg/kg	5	5	100%	--	--	23	32	27	31	31	31	Normal
RAD_D	Cesium-137	pCi/g	6	6	100%	--	--	0.28	2.8	1.4	8.4	2.3	2.8	Max detect
RAD_D	Gross alpha	pCi/g	6	5	83%	5.0	5.0	4.7	7.8	5.2	7.9	6.6	6.6	Normal
RAD_D	Gross beta	pCi/g	6	6	100%	--	--	24	44	34	45	42	42	Normal
RAD_D	Plutonium-238	pCi/g	6	1	17%	0.010	0.060	0.036	0.036	0.019	0.064	0.029	0.029	Normal
RAD_D	Plutonium-239	pCi/g	6	1	17%	0.010	0.030	0.020	0.020	0.010	0.024	0.015	0.015	Normal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	12	13	13	13	13	13	Normal
RAD_D	Radium-226	pCi/g	6	6	100%	--	--	0.79	1.3	0.99	1.1	1.1	1.1	Lognormal
RAD_D	Strontium-90	pCi/g	6	6	100%	--	--	0.11	2.8	0.73	6.1	1.6	2.8	Max detect
RAD_D	Technetium-99	pCi/g	6	1	17%	1.0	2.0	1.1	1.1	0.68	1.0	0.92	0.92	Normal
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0068	0.0088	0.0080	0.0088	0.0087	0.0087	Normal
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	5	1	20%	0.33	0.35	0.057	0.057	0.15	0.32	0.20	0.057	Max detect
SVOA	Di-n-butylphthalate	mg/kg	5	1	20%	0.33	0.35	0.055	0.055	0.15	0.33	0.20	0.055	Max detect

Table C-2. Summary of Statistics for Shallow Zone Soils from 216-B-43 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
SVOA	Pentachlorophenol	mg/kg	5	1	20%	1.7	1.8	0.15	0.15	0.73	4.1	1.0	0.15	Max detect
VOA	Acetone	mg/kg	5	1	20%	0.0080	0.010	0.082	0.082	0.020	0.96	0.053	0.082	Max detect
VOA	Methylene chloride	mg/kg	5	1	20%	0.0040	0.0060	0.031	0.031	0.0082	0.18	0.020	0.031	Max detect

EPC = exposure point concentration.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-3. Summary of Statistics for Shallow Zone Soils from 216-B-44 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	6	6	100%	--	--	3,760	5,680	4,363	5,004	4,942	5,004	Lognormal
METAL	Arsenic	mg/kg	6	6	100%	--	--	1.1	2.2	1.9	2.5	2.2	2.2	Max detect
METAL	Barium	mg/kg	6	6	100%	--	--	51	80	63	72	71	72	Lognormal
METAL	Beryllium	mg/kg	6	6	100%	--	--	0.23	0.45	0.34	0.46	0.42	0.42	Normal
METAL	Calcium	mg/kg	6	6	100%	--	--	6,200	10,700	7,590	9,140	8,947	9,140	Lognormal
METAL	Chromium	mg/kg	6	6	100%	--	--	4.6	7.4	5.5	6.5	6.3	6.5	Lognormal
METAL	Cobalt	mg/kg	6	6	100%	--	--	6.7	10	7.8	9.0	8.9	9.0	Lognormal
METAL	Copper	mg/kg	6	6	100%	--	--	8.9	14	11	13	13	13	Lognormal
METAL	Iron	mg/kg	6	6	100%	--	--	11,400	15,800	13,367	14,848	14,679	14,848	Lognormal
METAL	Lead	mg/kg	6	6	100%	--	--	3.0	5.3	3.8	4.6	4.5	4.6	Lognormal
METAL	Magnesium	mg/kg	6	6	100%	--	--	2,780	3,990	3,210	3,612	3,572	3,612	Lognormal
METAL	Manganese	mg/kg	6	6	100%	--	--	216	310	254	286	282	286	Lognormal
METAL	Nickel	mg/kg	6	6	100%	--	--	4.2	9.0	7.3	10	9.0	9.0	Max detect
METAL	Potassium	mg/kg	6	6	100%	--	--	733	1,380	987	1,196	1,161	1,196	Lognormal
METAL	Silver	mg/kg	6	1	17%	1.7	2.1	2.4	2.4	1.1	1.8	1.6	1.8	Lognormal
METAL	Sodium	mg/kg	6	6	100%	--	--	120	250	185	248	227	248	Lognormal
METAL	Uranium	mg/kg	6	1	17%	0.50	1.0	1.5	1.5	0.55	1.4	0.94	1.4	Lognormal
METAL	Vanadium	mg/kg	6	6	100%	--	--	20	28	23	26	26	26	Lognormal
METAL	Zinc	mg/kg	6	6	100%	--	--	24	34	28	31	31	31	Lognormal

Table C-3. Summary of Statistics for Shallow Zone Soils from 216-B-44 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
RAD_D	Cesium-137	pCi/g	6	6	100%	--	--	0.25	3.7	1.6	12	2.7	3.7	Max detect
RAD_D	Gross alpha	pCi/g	6	6	100%	--	--	5.3	15	8.2	12	11	12	Lognormal
RAD_D	Gross beta	pCi/g	6	6	100%	--	--	28	48	35	41	41	41	Lognormal
RAD_D	Plutonium-239	pCi/g	6	1	17%	0.010	0.010	0.010	0.010	0.0058	0.0078	0.0075	0.0075	Normal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	12	13	13	13	13	13	Normal
RAD_D	Radium-226	pCi/g	6	6	100%	--	--	0.70	1.3	1.0	1.3	1.2	1.2	Normal
RAD_D	Strontium-90	pCi/g	6	6	100%	--	--	0.090	1.7	0.55	3.3	1.0	1.7	Max detect
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0077	0.010	0.0089	0.0098	0.0097	0.0097	Normal
SVOA	2-chloronaphthalene	mg/kg	6	2	33%	0.34	0.38	0.065	0.074	0.14	0.27	0.19	0.074	Max detect
SVOA	Benzoic acid	mg/kg	4	1	25%	1.6	1.9	0.058	0.058	0.66	13.589	1.1	0.058	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	1	17%	0.075	0.38	0.12	0.12	0.14	0.37	0.19	0.12	Max detect
SVOA	Di-n-butylphthalate	mg/kg	6	1	17%	0.062	0.38	0.062	0.062	0.13	0.45	0.19	0.062	Max detect
SVOA	Phenol	mg/kg	6	1	17%	0.33	0.38	0.12	0.12	0.17	0.19	0.19	0.12	Max detect
VOA	Methylene chloride	mg/kg	6	1	17%	0.0080	0.019	0.022	0.022	0.0093	0.020	0.015	0.020	Lognormal
VOA	Toluene	mg/kg	6	1	17%	0.0050	0.0060	0.0040	0.0040	0.0028	0.0034	0.0033	0.0034	Lognormal

EPC = exposure point concentration.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-4. Summary of Statistics for Shallow Zone Soils from 216-B-45 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Nitrate	mg/kg	1	1	100%	--	--	5.9	5.9	5.9	--	--	5.9	Max detect
GENCH	Sulfate	mg/kg	1	1	100%	--	--	8.7	8.7	8.7	--	--	8.7	Max detect
GENOR	Total organic carbon	mg/kg	1	1	100%	--	--	92	92	92	--	--	92	Max detect
METAL	Aluminum	mg/kg	7	7	100%	--	--	3,520	7,130	4,790	5,979	5,780	5,979	Lognormal
METAL	Arsenic	mg/kg	7	7	100%	--	--	1.3	2.2	1.8	2.1	2.0	2.0	Normal
METAL	Barium	mg/kg	7	7	100%	--	--	55	77	64	69	69	69	Lognormal
METAL	Beryllium	mg/kg	7	6	86%	0.20	0.20	0.23	0.73	0.36	0.74	0.50	0.73	Max detect
METAL	Cadmium	mg/kg	7	3	43%	0.60	0.63	0.80	1.3	0.63	1.4	0.95	0.95	Normal
METAL	Calcium	mg/kg	7	7	100%	--	--	4,920	9,060	6,660	7,890	7,686	7,890	Lognormal
METAL	Chromium	mg/kg	7	5	71%	4.7	6.8	4.4	12	6.2	12	8.7	12	Lognormal
METAL	Cobalt	mg/kg	7	7	100%	--	--	5.4	13	8.0	10	9.8	10	Lognormal
METAL	Copper	mg/kg	7	7	100%	--	--	9.1	15	11	13	13	13	Lognormal
METAL	Iron	mg/kg	7	7	100%	--	--	10,100	24,700	15,129	19,528	18,667	19,528	Lognormal
METAL	Lead	mg/kg	7	7	100%	--	--	3.1	28	7.3	18	14	18	Lognormal
METAL	Magnesium	mg/kg	7	7	100%	--	--	2,400	5,270	3,527	4,437	4,254	4,437	Lognormal
METAL	Manganese	mg/kg	7	7	100%	--	--	196	368	259	304	299	304	Lognormal
METAL	Nickel	mg/kg	7	6	86%	3.8	3.8	5.7	12	7.0	14	9.3	9.3	Normal
METAL	Potassium	mg/kg	7	7	100%	--	--	684	1,320	931	1,089	1,071	1,089	Lognormal
METAL	Silver	mg/kg	7	2	29%	0.14	0.85	1.6	1.7	0.72	4.6	1.2	1.7	Max detect
METAL	Sodium	mg/kg	7	6	86%	133	133	138	436	238	529	333	333	Normal
METAL	Thallium	mg/kg	7	1	14%	0.38	0.42	0.11	0.11	0.19	0.24	0.22	0.11	Max detect
METAL	Vanadium	mg/kg	7	7	100%	--	--	17	47	29	41	37	41	Lognormal
METAL	Zinc	mg/kg	7	7	100%	--	--	21	46	31	38	37	38	Lognormal
RAD_D	Cesium-137	pCi/g	7	6	86%	0.20	0.20	0.099	2.5	0.53	2.9	1.2	2.5	Max detect
RAD_D	Gross alpha	pCi/g	7	7	100%	--	--	1.9	15	8.6	20	12	12	Normal
RAD_D	Gross beta	pCi/g	7	7	100%	--	--	2.8	39	29	140	38	38	Normal
RAD_D	Plutonium-239	pCi/g	6	1	17%	0.010	0.010	0.010	0.010	0.0058	0.0078	0.0075	0.0075	Normal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	11	13	12	12	12	12	Lognormal
RAD_D	Radium-226	pCi/g	6	5	83%	0.60	0.60	0.67	0.82	0.67	1.0	0.82	0.82	Max detect
RAD_D	Strontium-90	pCi/g	7	7	100%	--	--	0.20	1.3	0.47	1.0	0.75	1.0	Lognormal

Table C-4. Summary of Statistics for Shallow Zone Soils from 216-B-45 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
RAD_D	Technetium-99	pCi/g	7	1	14%	0.90	70	1.0	1.0	5.5	124	15	1.0	Max detect
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0069	0.0086	0.0078	0.0085	0.0084	0.0084	Normal
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	5	3	60%	0.35	0.35	0.021	0.073	0.096	1.00	0.17	0.073	Max detect
SVOA	Diethylphthalate	mg/kg	5	1	20%	0.34	0.35	0.014	0.014	0.14	4.2	0.21	0.014	Max detect
SVOA	Hexadecanoic acid (9CI)	mg/kg	1	1	100%	--	--	0.19	0.19	0.19	--	--	0.19	Max detect
VOA	Toluene	mg/kg	5	3	60%	0.0050	0.0050	0.0010	0.0030	0.0024	0.0048	0.0032	0.0030	Max detect

EPC = exposure point concentration.
GENCH = general chemical.
GENOR = general organic.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-5. Summary of Statistics for Shallow Zone Soils from 216-B-47 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	6	6	100%	--	--	3,300	4,850	4,268	4,830	4,718	4,718	Normal
METAL	Arsenic	mg/kg	6	6	100%	--	--	1.7	2.6	2.0	2.3	2.3	2.3	Lognormal
METAL	Barium	mg/kg	6	6	100%	--	--	52	77	67	77	75	75	Normal
METAL	Beryllium	mg/kg	6	3	50%	0.20	0.39	0.26	0.30	0.22	0.36	0.28	0.28	Normal
METAL	Cadmium	mg/kg	6	2	33%	0.78	0.83	1.1	1.3	0.67	1.4	1.0	1.0	Normal
METAL	Calcium	mg/kg	6	6	100%	--	--	5,990	9,690	7,267	8,536	8,371	8,536	Lognormal
METAL	Chromium	mg/kg	6	6	100%	--	--	5.3	9.6	7.2	9.0	8.6	9.0	Lognormal
METAL	Cobalt	mg/kg	6	4	67%	10	10	7.3	8.0	6.9	8.5	8.0	8.0	Max detect
METAL	Copper	mg/kg	6	6	100%	--	--	11	13	11	12	12	12	Lognormal
METAL	Iron	mg/kg	6	6	100%	--	--	11,800	15,400	13,100	14,578	14,435	14,578	Lognormal
METAL	Lead	mg/kg	6	6	100%	--	--	3.0	5.8	3.9	5.0	4.8	5.0	Lognormal
METAL	Magnesium	mg/kg	6	6	100%	--	--	2,870	3,490	3,267	3,521	3,490	3,490	Max detect
METAL	Manganese	mg/kg	6	6	100%	--	--	220	282	247	268	266	268	Lognormal

Table C-5. Summary of Statistics for Shallow Zone Soils from 216-B-47 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Nickel	mg/kg	6	6	100%	--	--	6.8	14	8.7	11	11	11	Lognormal
METAL	Potassium	mg/kg	6	6	100%	--	--	726	11,600	2,814	18,655	6,360	11,600	Max detect
METAL	Sodium	mg/kg	6	6	100%	--	--	111	288	194	319	258	258	Normal
METAL	Uranium	mg/kg	6	1	17%	0.50	8.0	1.1	1.1	1.1	10	2.3	1.1	Max detect
METAL	Vanadium	mg/kg	6	6	100%	--	--	17	29	23	28	27	27	Normal
METAL	Zinc	mg/kg	6	6	100%	--	--	25	32	28	31	30	30	Normal
PEST	Dichlorodiphenyl-trichloroethane	mg/kg	6	1	17%	0.032	0.034	0.011	0.011	0.016	0.019	0.018	0.011	Max detect
RAD_D	Cesium-137	pCi/g	6	6	100%	--	--	0.59	53	10	1,844	28	53	Max detect
RAD_D	Gross alpha	pCi/g	6	6	100%	--	--	4.7	9.4	7.6	9.7	8.9	8.9	Normal
RAD_D	Gross beta	pCi/g	6	6	100%	--	--	31	54	42	52	49	52	Lognormal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	11	155	36	265	84	155	Max detect
RAD_D	Radium-226	pCi/g	6	5	83%	0.70	0.70	0.57	10	2.4	33	5.6	10	Max detect
RAD_D	Strontium-90	pCi/g	6	6	100%	--	--	0.17	6.9	1.5	57	3.7	6.9	Max detect
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0077	0.13	0.030	0.28	0.072	0.13	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.33	0.35	0.081	0.27	0.17	0.26	0.22	0.22	Normal
SVOA	Di-n-butylphthalate	mg/kg	6	1	17%	0.33	0.36	0.037	0.037	0.15	0.37	0.19	0.037	Max detect
SVOA	Pentachlorophenol	mg/kg	6	2	33%	1.6	1.8	0.059	0.15	0.60	11	0.92	0.15	Max detect
VOA	Toluene	mg/kg	6	1	17%	0.0050	0.0060	0.0010	0.0010	0.0023	0.0037	0.0029	0.0010	Max detect

EPC = exposure point concentration.
PEST = pesticide.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-6. Summary of Statistics for Shallow Zone Soils from 216-B-48 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	6	6	100%	--	--	3,910	6,590	4,742	5,695	5,566	5,695	Lognormal
METAL	Arsenic	mg/kg	6	6	100%	--	--	1.0	2.1	1.8	2.3	2.1	2.1	Normal
METAL	Barium	mg/kg	6	6	100%	--	--	56	86	67	76	75	76	Lognormal
METAL	Beryllium	mg/kg	6	4	67%	0.20	0.38	0.23	0.44	0.28	0.57	0.38	0.38	Normal
METAL	Calcium	mg/kg	6	6	100%	--	--	4,650	7,960	6,237	8,095	7,550	7,550	Normal
METAL	Chromium	mg/kg	6	6	100%	--	--	5.1	9.8	6.7	8.4	8.1	8.4	Lognormal
METAL	Cobalt	mg/kg	6	5	83%	9.1	9.1	6.6	11	7.5	9.9	9.1	9.1	Normal
METAL	Copper	mg/kg	6	6	100%	--	--	8.9	12	10	11	11	11	Normal
METAL	Iron	mg/kg	6	6	100%	--	--	11,600	19,100	14,200	16,849	16,470	16,849	Lognormal
METAL	Lead	mg/kg	6	6	100%	--	--	2.9	5.4	4.4	5.5	5.1	5.1	Normal
METAL	Magnesium	mg/kg	6	6	100%	--	--	2,850	3,950	3,377	3,756	3,709	3,756	Lognormal
METAL	Manganese	mg/kg	6	6	100%	--	--	226	325	259	292	289	292	Lognormal
METAL	Nickel	mg/kg	6	6	100%	--	--	6.2	17	10.0	15	13	15	Lognormal
METAL	Potassium	mg/kg	6	6	100%	--	--	886	1,470	1,095	1,335	1,293	1,335	Lognormal
METAL	Sodium	mg/kg	6	6	100%	--	--	100	249	185	283	237	237	Normal
METAL	Uranium	mg/kg	6	3	50%	0.50	0.70	1.3	2.5	1.0	7.5	1.8	2.5	Max detect
METAL	Vanadium	mg/kg	6	6	100%	--	--	20	40	27	35	33	35	Lognormal
METAL	Zinc	mg/kg	6	6	100%	--	--	26	38	30	34	34	34	Lognormal
PEST	Dichlorodiphenyltrichloroethane	mg/kg	6	1	17%	0.032	0.034	0.0062	0.0062	0.015	0.023	0.018	0.0062	Max detect
RAD_D	Cesium-137	pCi/g	6	6	100%	--	--	0.14	2.8	1.1	25	2.0	2.8	Max detect
RAD_D	Gross alpha	pCi/g	6	5	83%	3.0	3.0	4.7	7.8	5.9	15	7.9	7.8	Max detect
RAD_D	Gross beta	pCi/g	6	6	100%	--	--	30	66	39	52	50	52	Lognormal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	10	16	14	15	15	15	Normal
RAD_D	Radium-226	pCi/g	6	5	83%	0.50	0.50	0.65	1.6	1.1	3.2	1.5	1.5	Normal

Table C-6. Summary of Statistics for Shallow Zone Soils from 216-B-48 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
RAD_D	Strontium-90	pCi/g	6	6	100%	--	--	0.16	9.8	1.9	129	5.1	9.8	Max detect
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0074	0.013	0.010	0.013	0.012	0.012	Normal
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.34	0.56	0.10	0.28	0.20	0.31	0.26	0.26	Normal
VOA	Toluene	mg/kg	6	2	33%	0.0050	0.0060	0.0010	0.0010	0.0021	0.0040	0.0028	0.0010	Max detect

EPC = exposure point concentration.
PEST = pesticide.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-7. Summary of Statistics for Shallow Zone Soils from 216-B-49 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	6	6	100%	--	--	3,090	5,600	3,922	5,138	4,852	5,138	Lognormal
METAL	Arsenic	mg/kg	6	6	100%	--	--	1.2	4.1	1.8	3.2	2.8	3.2	Lognormal
METAL	Barium	mg/kg	6	6	100%	--	--	47	66	55	62	61	62	Lognormal
METAL	Beryllium	mg/kg	6	6	100%	--	--	0.26	0.44	0.32	0.41	0.39	0.41	Lognormal
METAL	Cadmium	mg/kg	6	1	17%	0.59	0.80	0.89	0.89	0.43	0.68	0.62	0.68	Lognormal
METAL	Calcium	mg/kg	6	6	100%	--	--	5,890	7,610	6,587	7,247	7,179	7,179	Normal
METAL	Chromium	mg/kg	6	6	100%	--	--	3.8	12	6.3	11	9.0	11	Lognormal
METAL	Cobalt	mg/kg	6	6	100%	--	--	5.2	11	7.0	10.0	9.1	10.0	Lognormal

Table C-7. Summary of Statistics for Shallow Zone Soils from 216-B-49 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Copper	mg/kg	6	6	100%	--	--	8.3	77	21	84	44	77	Max detect
METAL	Iron	mg/kg	6	6	100%	--	--	8,820	19,800	12,523	18,646	16,598	18,646	Lognormal
METAL	Lead	mg/kg	6	6	100%	--	--	2.0	7.7	4.0	7.0	5.7	7.0	Lognormal
METAL	Magnesium	mg/kg	6	6	100%	--	--	2,370	3,980	2,993	3,805	3,628	3,805	Lognormal
METAL	Manganese	mg/kg	6	6	100%	--	--	182	312	231	285	274	285	Lognormal
METAL	Nickel	mg/kg	6	6	100%	--	--	4.9	11	7.0	9.9	9.0	9.9	Lognormal
METAL	Potassium	mg/kg	6	6	100%	--	--	732	1,160	936	1,104	1,070	1,070	Normal
METAL	Silver	mg/kg	4	2	50%	1.2	1.4	1.5	1.8	1.2	5.8	1.8	1.8	Max detect
METAL	Sodium	mg/kg	6	6	100%	--	--	108	316	199	306	259	306	Lognormal
METAL	Vanadium	mg/kg	6	6	100%	--	--	12	43	24	52	36	43	Max detect
METAL	Zinc	mg/kg	6	6	100%	--	--	19	38	26	36	33	36	Lognormal
RAD_D	Cesium-137	pCi/g	6	4	67%	0.91	1.6	0.068	1.5	0.58	6.2	1.0	1.5	Max detect
RAD_D	Gross alpha	pCi/g	6	4	67%	5.9	6.4	2.1	7.3	4.0	6.6	5.5	6.6	Lognormal
RAD_D	Gross beta	pCi/g	6	2	33%	27	62	32	64	32	60	46	60	Lognormal
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	10	14	12	13	13	13	Lognormal
RAD_D	Radium-226	pCi/g	6	5	83%	0.80	0.80	0.64	0.76	0.65	0.82	0.75	0.75	Normal
RAD_D	Strontium-90	pCi/g	6	4	67%	2.4	15	1.2	8.1	4.5	25	7.2	7.2	Normal
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0060	0.0071	0.0065	0.0069	0.0069	0.0069	Lognormal
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.34	0.34	0.068	0.071	0.14	0.24	0.18	0.071	Max detect
SVOA	Di-n-butylphthalate	mg/kg	6	2	33%	0.34	0.82	2.1	3.1	1.0	31	2.1	3.1	Max detect
VOA	Acetone	mg/kg	6	2	33%	0.010	0.013	0.018	0.059	0.016	0.12	0.034	0.059	Max detect
VOA	Methylene chloride	mg/kg	6	2	33%	0.0050	0.0080	0.023	0.026	0.010	0.089	0.019	0.026	Max detect

EPC = exposure point concentration.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-8. Summary of Statistics for Shallow Zone Soils from 216-B-50 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	6	6	100%	--	--	3,890	4,630	4,183	4,437	4,420	4,437	Lognormal
METAL	Arsenic	mg/kg	6	6	100%	--	--	1.0	1.8	1.6	2.0	1.8	1.8	Max detect
METAL	Barium	mg/kg	6	6	100%	--	--	60	71	64	67	67	67	Lognormal
METAL	Beryllium	mg/kg	6	6	100%	--	--	0.28	0.44	0.35	0.41	0.40	0.41	Lognormal
METAL	Calcium	mg/kg	6	6	100%	--	--	4,180	7,850	6,433	8,165	7,605	7,605	Normal
METAL	Chromium	mg/kg	6	6	100%	--	--	4.5	6.8	5.5	6.3	6.2	6.3	Lognormal
METAL	Cobalt	mg/kg	6	6	100%	--	--	6.2	7.7	7.0	7.6	7.5	7.5	Normal
METAL	Copper	mg/kg	6	6	100%	--	--	9.1	12	10	11	11	11	Lognormal
METAL	Iron	mg/kg	6	6	100%	--	--	11,200	14,500	12,617	13,867	13,737	13,737	Normal
METAL	Lead	mg/kg	6	6	100%	--	--	2.7	4.6	3.7	4.5	4.3	4.3	Normal
METAL	Magnesium	mg/kg	6	6	100%	--	--	2,900	3,380	3,117	3,273	3,262	3,273	Lognormal
METAL	Manganese	mg/kg	6	6	100%	--	--	219	283	253	273	270	270	Normal
METAL	Nickel	mg/kg	6	6	100%	--	--	5.6	9.0	7.4	8.8	8.4	8.4	Normal
METAL	Potassium	mg/kg	6	4	67%	905	1,000	975	1,450	925	1,651	1,241	1,241	Normal
METAL	Sodium	mg/kg	6	6	100%	--	--	94	275	182	272	232	232	Normal
METAL	Uranium	mg/kg	6	1	17%	0.30	0.80	1.6	1.6	0.49	1.8	0.94	1.6	Max detect
METAL	Vanadium	mg/kg	6	6	100%	--	--	16	27	21	26	25	25	Normal
METAL	Zinc	mg/kg	6	6	100%	--	--	24	32	27	29	29	29	Lognormal
RAD_D	Cesium-137	pCi/g	6	6	100%	--	--	0.39	3.7	1.3	5.0	2.3	3.7	Max detect
RAD_D	Gross alpha	pCi/g	6	5	83%	4.0	4.0	0.92	12	6.0	47	9.6	9.6	Normal
RAD_D	Gross beta	pCi/g	6	6	100%	--	--	12	49	32	59	42	42	Normal
RAD_D	Plutonium-238	pCi/g	6	1	17%	0.010	0.030	0.0091	0.0091	0.0082	0.014	0.011	0.0091	Max detect
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	10.0	13	12	13	13	13	Normal
RAD_D	Radium-226	pCi/g	6	5	83%	0.60	0.60	0.64	1.1	0.83	1.6	1.1	1.1	Normal
RAD_D	Strontium-90	pCi/g	6	3	50%	0.10	0.31	0.097	0.24	0.13	0.27	0.18	0.24	Max detect
RAD_D	Technetium-99	pCi/g	6	1	17%	0.70	1.1	1.7	1.7	0.68	1.4	1.1	1.4	Lognormal
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0062	0.0087	0.0075	0.0085	0.0083	0.0083	Normal
SVOA	Di-n-butylphthalate	mg/kg	2	2	100%	--	--	0.082	0.79	0.44	3.33E+14	2.7	0.79	Max detect

EPC = exposure point concentration.
RAD_D = decayed radiological.
UCL = upper confidence limit.
SVOA = semi-volatile organic analyte.

Table C-9. Summary of Statistics for Deep Zone Soils from 216-B-43 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Cyanide	mg/kg	18	5	28%	1.0	1.2	0.80	2.9	0.86	1.1	1.1	1.1	Lognormal
GENCH	Nitrate	mg/kg	3	3	100%	--	--	266	565	421	1,674	674	565	Max detect
GENCH	Nitrite	mg/kg	3	3	100%	--	--	7.0	48	33	2.24E+06	71	48	Max detect
GENCH	Phosphate	mg/kg	3	3	100%	--	--	4.1	20	10	3,543	24	20	Max detect
GENCH	Sulfate	mg/kg	3	3	100%	--	--	127	200	166	299	228	200	Max detect
GENOR	Total organic carbon	mg/kg	3	3	100%	--	--	47	106	71	369	124	106	Max detect
METAL	Aluminum	mg/kg	12	12	100%	--	--	1,990	10,300	5,035	6,711	6,262	6,711	Lognormal
METAL	Antimony	mg/kg	18	1	6%	2.8	11	5.8	5.8	2.8	3.3	3.3	3.3	Lognormal
METAL	Arsenic	mg/kg	18	18	100%	--	--	0.54	2.9	1.9	2.3	2.1	2.1	Normal
METAL	Barium	mg/kg	18	18	100%	--	--	33	101	60	68	67	68	Lognormal
METAL	Beryllium	mg/kg	18	15	83%	0.21	0.36	0.22	0.42	0.29	0.35	0.32	0.32	Normal
METAL	Bismuth	mg/kg	3	2	67%	0.22	0.22	0.69	1.2	0.68	2.38E+06	1.6	1.2	Max detect
METAL	Cadmium	mg/kg	18	7	39%	0.61	0.83	0.50	1.8	0.61	0.82	0.80	0.82	Lognormal
METAL	Calcium	mg/kg	18	18	100%	--	--	4,240	11,400	6,707	7,540	7,436	7,540	Lognormal
METAL	Chromium	mg/kg	18	17	94%	4.9	4.9	1.7	119	14	19	25	19	Lognormal
METAL	Cobalt	mg/kg	18	16	89%	8.2	8.7	3.2	8.8	6.0	6.9	6.7	6.7	Normal
METAL	Copper	mg/kg	18	17	94%	9.8	9.8	5.5	19	11	13	13	13	Normal
METAL	Iron	mg/kg	18	18	100%	--	--	5,020	20,600	12,562	14,772	14,188	14,188	Normal
METAL	Lead	mg/kg	17	17	100%	--	--	2.2	6.2	3.8	4.3	4.2	4.3	Lognormal
METAL	Magnesium	mg/kg	18	18	100%	--	--	1,480	24,200	4,469	5,489	6,517	5,489	Lognormal
METAL	Manganese	mg/kg	18	18	100%	--	--	119	294	231	252	247	247	Normal
METAL	Mercury	mg/kg	18	5	28%	0.050	0.050	0.030	0.18	0.043	0.054	0.061	0.054	Lognormal
METAL	Nickel	mg/kg	18	18	100%	--	--	5.7	67	12	15	18	15	Lognormal
METAL	Potassium	mg/kg	18	17	94%	995	995	502	1,470	857	996	969	996	Lognormal
METAL	Silver	mg/kg	18	6	33%	0.13	2.1	1.1	2.5	0.88	2.4	1.1	1.1	Normal
METAL	Sodium	mg/kg	18	17	94%	131	131	147	6,010	1,545	4,629	2,271	4,629	Lognormal
METAL	Thallium	mg/kg	18	1	6%	0.060	0.42	0.11	0.11	0.18	0.26	0.20	0.11	Max detect
METAL	Uranium	mg/kg	20	9	45%	0.40	1.0	1.4	31	5.2	27	8.7	27	Lognormal
METAL	Vanadium	mg/kg	18	17	94%	23	23	7.4	50	24	30	28	30	Lognormal
METAL	Zinc	mg/kg	18	18	100%	--	--	14	37	27	30	29	29	Normal

Table C-9. Summary of Statistics for Deep Zone Soils from 216-B-43 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
PEST	Dichlorodiphenyltrichloroethane	mg/kg	13	1	8%	0.016	0.034	0.0021	0.0021	0.014	0.022	0.016	0.0021	Max detect
RAD_D	Cesium-134	pCi/g	16	1	6%	0.030	0.060	8.87E-04	8.87E-04	0.017	0.031	0.019	8.87E-04	Max detect
RAD_D	Cesium-137	pCi/g	21	12	57%	0.020	0.040	0.28	2.60E+06	162,489	4.83E+16	380,308	2.60E+06	Max detect
RAD_D	Cobalt-60	pCi/g	21	9	43%	0.020	70	0.0083	0.42	2.3	32	5.2	0.42	Max detect
RAD_D	Gross alpha	pCi/g	21	16	76%	1.0	5.0	4.7	382	29	49	60	49	Lognormal
RAD_D	Gross beta	pCi/g	21	17	81%	37	110	24	1.74E+07	1.20E+06	1.90E+11	2.68E+06	1.74E+07	Max detect
RAD_D	Plutonium-238	pCi/g	21	5	24%	0.010	0.060	0.0091	7.8	0.47	0.77	1.1	0.77	Lognormal
RAD_D	Plutonium-239	pCi/g	16	1	6%	0.010	0.030	0.020	0.020	0.0072	0.0090	0.0091	0.0090	Lognormal
RAD_D	Plutonium-239/240	pCi/g	5	5	100%	--	--	0.10	405	110	3.10E+17	275	405	Max detect
RAD_D	Potassium-40	pCi/g	16	16	100%	--	--	12	17	14	15	15	15	Lognormal
RAD_D	Radium-226	pCi/g	16	14	88%	0.60	1.5	0.71	1.3	0.90	1.1	0.99	0.99	Normal
RAD_D	Strontium-90	pCi/g	21	14	67%	0.040	0.20	0.045	5.00E+06	358,556	7.54E+18	785,652	5.00E+06	Max detect
RAD_D	Technetium-99	pCi/g	21	8	38%	0.70	70	1.1	210	46	1,369	68	210	Max detect
RAD_D	Thorium-228	pCi/g	16	16	100%	--	--	0.0058	0.012	0.0082	0.0088	0.0087	0.0088	Lognormal
RAD_D	Tritium	pCi/g	5	5	100%	--	--	17	100	42	149	74	100	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	13	5	38%	0.063	0.37	0.041	2.2	0.29	0.56	0.57	0.56	Lognormal
SVOA	Butylbenzylphthalate	mg/kg	14	2	14%	0.33	0.37	0.36	1.0	0.24	0.31	0.35	0.31	Lognormal
SVOA	Diethylphthalate	mg/kg	14	1	7%	0.33	0.37	0.12	0.12	0.17	0.18	0.17	0.12	Max detect
SVOA	Di-n-butylphthalate	mg/kg	14	5	36%	0.33	3.9	0.055	0.70	0.37	0.63	0.60	0.63	Lognormal
SVOA	Di-n-octylphthalate	mg/kg	14	2	14%	0.33	0.37	0.024	0.038	0.15	0.24	0.18	0.038	Max detect
SVOA	Dodecane	mg/kg	1	1	100%	--	--	2.2	2.2	2.2	--	--	2.2	Max detect
SVOA	Hexadecane-	mg/kg	1	1	100%	--	--	1.7	1.7	1.7	--	--	1.7	Max detect
SVOA	Isophorone	mg/kg	14	1	7%	0.33	0.37	0.19	0.19	0.17	0.18	0.18	0.18	Lognormal
SVOA	Pentachlorophenol	mg/kg	14	2	14%	0.085	1.8	0.074	0.15	0.70	2.1	0.85	0.15	Max detect
SVOA	Pentadecane	mg/kg	1	1	100%	--	--	7.0	7.0	7.0	--	--	7.0	Max detect
SVOA	Tetradecane	mg/kg	1	1	100%	--	--	9.6	9.6	9.6	--	--	9.6	Max detect
SVOA	Tributyl phosphate	mg/kg	3	3	100%	--	--	2.8	94	43	1.04E+15	121	94	Max detect
SVOA	Tridecane	mg/kg	1	1	100%	--	--	7.7	7.7	7.7	--	--	7.7	Max detect
VOA	2-hexanone	mg/kg	14	1	7%	0.010	0.012	0.0010	0.0010	0.0048	0.0064	0.0054	0.0010	Max detect
VOA	Acetone	mg/kg	14	3	21%	0.0080	0.057	0.0060	0.082	0.014	0.023	0.024	0.023	Lognormal

Table C-9. Summary of Statistics for Deep Zone Soils from 216-B-43 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
VOA	Methylene chloride	mg/kg	14	2	14%	0.0040	0.025	0.0010	0.031	0.0054	0.0085	0.0091	0.0085	Lognormal
VOA	Styrene	mg/kg	14	1	7%	0.0050	0.0060	0.0010	0.0010	0.0025	0.0029	0.0027	0.0010	Max detect
VOA	Toluene	mg/kg	14	3	21%	0.0050	0.0060	0.0020	0.083	0.0083	0.010	0.018	0.010	Lognormal

EPC = exposure point concentration.
GENCH = general chemical.
PEST = pesticide.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-10. Summary of Statistics for Deep Zone Soils from 216-B-44 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Complex cyanide	mg/kg	5	5	100%	--	--	2.6	116	33	31,525	79	116	Max detect
GENCH	Cyanide	mg/kg	11	3	27%	0.20	1.3	3.3	7.8	1.9	8.6	3.3	7.8	Max detect
GENCH	Free cyanide	mg/kg	5	5	100%	--	--	0.70	3.5	2.4	7.8	3.4	3.4	Normal
GENCH	Nitrate	mg/kg	6	6	100%	--	--	81	1,040	561	4,034	876	876	Normal
GENCH	Nitrite	mg/kg	6	4	67%	0.80	0.80	2.1	43	11	17,264	25	43	Max detect
GENCH	Phosphate	mg/kg	6	6	100%	--	--	2.9	112	58	3,110	94	94	Normal
GENCH	Sulfate	mg/kg	6	6	100%	--	--	116	354	239	413	315	315	Normal
GENOR	Total organic carbon	mg/kg	6	6	100%	--	--	21	55	35	50	45	50	Lognormal
METAL	Aluminum	mg/kg	12	12	100%	--	--	3,760	8,010	5,570	6,492	6,313	6,313	Normal
METAL	Arsenic	mg/kg	11	11	100%	--	--	1.1	5.1	2.5	3.2	3.0	3.2	Lognormal
METAL	Barium	mg/kg	12	12	100%	--	--	49	80	62	68	67	68	Lognormal
METAL	Beryllium	mg/kg	12	12	100%	--	--	0.23	0.45	0.30	0.34	0.34	0.34	Lognormal
METAL	Bismuth	mg/kg	5	2	40%	0.20	0.30	4.6	9.3	2.9	578,398	6.8	9.3	Max detect
METAL	Cadmium	mg/kg	12	3	25%	0.38	3.9	0.44	0.69	0.68	1.1	0.97	0.69	Max detect
METAL	Calcium	mg/kg	12	12	100%	--	--	6,090	10,700	7,663	8,345	8,313	8,345	Lognormal
METAL	Chromium	mg/kg	12	12	100%	--	--	4.6	13	8.4	11	10.0	10.0	Normal
METAL	Cobalt	mg/kg	12	10	83%	5.4	5.4	5.9	10	6.7	8.9	7.9	7.9	Normal
METAL	Copper	mg/kg	12	12	100%	--	--	8.9	18	13	14	14	14	Lognormal

Table C-10. Summary of Statistics for Deep Zone Soils from 216-B-44 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Iron	mg/kg	12	12	100%	--	--	11,400	25,900	16,142	18,342	18,184	18,342	Lognormal
METAL	Lead	mg/kg	11	11	100%	--	--	3.0	11	4.9	6.5	6.4	6.5	Lognormal
METAL	Magnesium	mg/kg	12	12	100%	--	--	2,780	4,920	3,934	4,455	4,361	4,361	Normal
METAL	Manganese	mg/kg	12	12	100%	--	--	216	325	265	282	281	282	Lognormal
METAL	Mercury	mg/kg	11	5	45%	0.050	0.070	0.020	0.14	0.054	0.095	0.076	0.095	Lognormal
METAL	Nickel	mg/kg	12	12	100%	--	--	4.2	94	19	36	33	36	Lognormal
METAL	Potassium	mg/kg	12	8	67%	595	981	733	1,380	780	1,076	946	946	Normal
METAL	Silver	mg/kg	11	1	9%	0.090	2.1	2.4	2.4	0.64	7.5	1.0	2.4	Max detect
METAL	Sodium	mg/kg	12	12	100%	--	--	120	3,970	1,388	8,266	2,145	3,970	Max detect
METAL	Thallium	mg/kg	11	4	36%	0.050	0.53	0.060	0.10	0.15	0.29	0.19	0.10	Max detect
METAL	Uranium	mg/kg	12	7	58%	0.50	1.0	1.5	95	25	6,674	43	95	Max detect
METAL	Vanadium	mg/kg	12	12	100%	--	--	20	68	34	42	41	42	Lognormal
METAL	Zinc	mg/kg	12	12	100%	--	--	24	53	33	38	38	38	Lognormal
RAD_D	Cesium-137	pCi/g	12	12	100%	--	--	0.25	2.20E+06	275,505	2.12E+20	626,220	2.20E+06	Max detect
RAD_D	Cobalt-60	pCi/g	12	4	33%	0.020	90	0.15	11	4.8	3,484	12	11	Max detect
RAD_D	Gross alpha	pCi/g	12	12	100%	--	--	5.3	1,792	253	4,398	541	1,792	Max detect
RAD_D	Gross beta	pCi/g	12	12	100%	--	--	28	1.45E+07	2.18E+06	7.11E+19	4.62E+06	1.45E+07	Max detect
RAD_D	Plutonium-238	pCi/g	12	6	50%	0.010	0.040	0.036	51	7.0	49,277	15	51	Max detect
RAD_D	Plutonium-239	pCi/g	6	1	17%	0.010	0.010	0.010	0.010	0.0058	0.0078	0.0075	0.0075	Normal
RAD_D	Plutonium-239/240	pCi/g	6	6	100%	--	--	0.43	626	183	1.80E+09	409	626	Max detect
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	12	13	13	13	13	13	Normal
RAD_D	Radium-226	pCi/g	6	6	100%	--	--	0.70	1.3	1.0	1.3	1.2	1.2	Normal
RAD_D	Strontium-90	pCi/g	12	12	100%	--	--	0.090	4.92E+06	717,594	2.61E+30	1.52E+06	4.92E+06	Max detect
RAD_D	Technetium-99	pCi/g	12	4	33%	0.90	60	100	200	55	63,503	95	200	Max detect
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0077	0.010	0.0089	0.0098	0.0097	0.0097	Normal
RAD_D	Tritium	pCi/g	6	5	83%	5.0	5.0	5.4	20	13	65	19	19	Normal
SVOA	2-chloronaphthalene	mg/kg	12	2	17%	0.33	0.38	0.065	0.074	0.16	0.20	0.18	0.074	Max detect
SVOA	Benzoic acid	mg/kg	10	1	10%	1.6	1.9	0.058	0.058	0.77	2.1	0.92	0.058	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	12	4	33%	0.075	0.38	0.023	0.12	0.13	0.24	0.16	0.12	Max detect
SVOA	Butylbenzylphthalate	mg/kg	12	1	8%	0.33	0.38	0.047	0.047	0.16	0.21	0.18	0.047	Max detect
SVOA	Di-n-butylphthalate	mg/kg	12	3	25%	0.062	0.38	0.039	0.14	0.14	0.23	0.17	0.14	Max detect
SVOA	Di-n-octylphthalate	mg/kg	12	4	33%	0.33	0.38	0.011	0.048	0.12	0.47	0.16	0.048	Max detect
SVOA	Hexadecane-	mg/kg	2	2	100%	--	--	0.36	4.1	2.2	3.30E+17	14	4.1	Max detect
SVOA	Hexadecanoic acid (9CI)	mg/kg	1	1	100%	--	--	0.21	0.21	0.21	--	--	0.21	Max detect

Table C-10. Summary of Statistics for Deep Zone Soils from 216-B-44 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
SVOA	Pentadecane	mg/kg	1	1	100%	--	--	1.1	1.1	1.1	--	--	1.1	Max detect
SVOA	Phenol	mg/kg	12	1	8%	0.33	0.38	0.12	0.12	0.17	0.18	0.18	0.12	Max detect
SVOA	Tetradecane	mg/kg	2	2	100%	--	--	0.95	21	11	7.83E+28	74	21	Max detect
SVOA	Tributyl phosphate	mg/kg	5	5	100%	--	--	0.59	15	4.1	241	9.9	15	Max detect
SVOA	Tridecane	mg/kg	2	2	100%	--	--	0.23	4.6	2.4	2.87E+26	16	4.6	Max detect
VOA	2-ethyl-1-hexanol	mg/kg	2	2	100%	--	--	0.0060	0.47	0.24	6.13E+54	1.7	0.47	Max detect
VOA	Acetone	mg/kg	10	1	10%	0.010	0.031	0.0040	0.0040	0.0087	0.013	0.011	0.0040	Max detect
VOA	Methylene chloride	mg/kg	10	1	10%	0.0050	0.019	0.022	0.022	0.0066	0.012	0.010	0.012	Lognormal
VOA	Propanoic acid, 2-methyl-	mg/kg	1	1	100%	--	--	0.090	0.090	0.090	--	--	0.090	Max detect
VOA	Toluene	mg/kg	10	1	10%	0.0050	0.0060	0.0040	0.0040	0.0027	0.0030	0.0030	0.0030	Lognormal

EPC = exposure point concentration.
GENCH = general chemical.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-11. Summary of Statistics for Deep Zone Soils from 216-B-45 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Cyanide	mg/kg	14	5	36%	0.20	1.1	0.30	1.6	0.61	0.95	0.82	0.95	Lognormal
GENCH	Nitrate	mg/kg	5	5	100%	--	--	5.9	681	244	1.15E+06	497	681	Max detect
GENCH	Nitrite	mg/kg	5	4	80%	0.80	0.80	0.90	40	14	518,808	31	40	Max detect
GENCH	Phosphate	mg/kg	5	3	60%	1.7	1.7	8.9	32	11	13,991	24	24	Normal
GENCH	Sulfate	mg/kg	7	7	100%	--	--	8.7	344	161	2,612	262	344	Max detect
GENOR	Total organic carbon	mg/kg	7	7	100%	--	--	51	92	66	80	78	80	Lognormal
METAL	Aluminum	mg/kg	14	14	100%	--	--	3,520	15,800	7,479	9,921	9,360	9,921	Lognormal
METAL	Arsenic	mg/kg	14	14	100%	--	--	0.67	3.2	1.9	2.4	2.2	2.2	Normal
METAL	Barium	mg/kg	14	14	100%	--	--	55	129	76	86	86	86	Lognormal
METAL	Beryllium	mg/kg	14	13	93%	0.20	0.20	0.23	0.73	0.37	0.48	0.43	0.43	Normal
METAL	Bismuth	mg/kg	7	5	71%	0.27	0.29	0.27	9.1	2.7	517	5.3	9.1	Max detect

Table C-11. Summary of Statistics for Deep Zone Soils from 216-B-45 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Cadmium	mg/kg	14	8	57%	0.36	0.80	0.59	2.7	0.90	1.7	1.2	1.7	Lognormal
METAL	Calcium	mg/kg	14	14	100%	--	--	4,920	12,500	8,164	9,409	9,198	9,409	Lognormal
METAL	Chromium	mg/kg	14	12	86%	4.7	6.8	4.4	17	8.9	13	11	11	Normal
METAL	Cobalt	mg/kg	14	14	100%	--	--	5.4	13	8.3	9.6	9.4	9.6	Lognormal
METAL	Copper	mg/kg	14	14	100%	--	--	9.1	24	14	17	17	17	Lognormal
METAL	Iron	mg/kg	14	14	100%	--	--	10,100	36,200	19,029	22,940	22,269	22,940	Lognormal
METAL	Lead	mg/kg	14	13	93%	2.9	2.9	3.1	28	7.3	12	11	12	Lognormal
METAL	Magnesium	mg/kg	14	14	100%	--	--	2,400	5,280	4,173	4,801	4,653	4,653	Normal
METAL	Manganese	mg/kg	14	14	100%	--	--	196	464	292	326	324	326	Lognormal
METAL	Mercury	mg/kg	8	2	25%	0.050	0.050	0.18	0.34	0.084	0.35	0.16	0.34	Max detect
METAL	Nickel	mg/kg	14	13	93%	3.8	3.8	5.7	135	21	42	37	42	Lognormal
METAL	Potassium	mg/kg	14	14	100%	--	--	624	1,590	1,027	1,182	1,161	1,182	Lognormal
METAL	Silver	mg/kg	14	2	14%	0.040	1.6	1.6	1.7	0.44	2.7	0.70	1.7	Max detect
METAL	Sodium	mg/kg	14	13	93%	133	133	138	9,270	2,737	28,522	4,362	9,270	Max detect
METAL	Thallium	mg/kg	14	6	43%	0.070	0.42	0.040	0.14	0.15	0.23	0.18	0.14	Max detect
METAL	Uranium	mg/kg	14	7	50%	0.50	0.60	0.36	55	13	1,056	22	55	Max detect
METAL	Vanadium	mg/kg	14	14	100%	--	--	17	100	44	59	55	59	Lognormal
METAL	Zinc	mg/kg	14	14	100%	--	--	21	60	37	44	42	44	Lognormal
RAD_D	Cesium-137	pCi/g	14	13	93%	0.20	0.20	0.099	4.83E+06	785,916	5.75E+27	1.54E+06	4.83E+06	Max detect
RAD_D	Cobalt-60	pCi/g	14	3	21%	0.020	480	0.074	0.57	21	165,049	51	0.57	Max detect
RAD_D	Gross alpha	pCi/g	14	14	100%	--	--	1.9	3,140	557	42,751	1,060	3,140	Max detect
RAD_D	Gross beta	pCi/g	14	14	100%	--	--	2.8	1.69E+07	2.66E+06	2.62E+19	5.24E+06	1.69E+07	Max detect
RAD_D	Plutonium-238	pCi/g	14	6	43%	0.0090	0.040	0.16	104	16	534,003	32	104	Max detect
RAD_D	Plutonium-239	pCi/g	7	2	29%	0.010	0.010	0.010	0.12	0.022	0.14	0.054	0.12	Max detect
RAD_D	Plutonium-239/240	pCi/g	7	6	86%	0.0045	0.0045	3.4	2,350	796	9.25E+20	1,544	2,350	Max detect
RAD_D	Potassium-40	pCi/g	7	7	100%	--	--	11	16	12	14	13	14	Lognormal
RAD_D	Radium-226	pCi/g	7	6	86%	0.60	0.60	0.67	1.8	0.83	1.4	1.2	1.4	Lognormal
RAD_D	Strontium-90	pCi/g	14	14	100%	--	--	0.20	4.46E+06	676,556	5.84E+25	1.34E+06	4.46E+06	Max detect
RAD_D	Technetium-99	pCi/g	14	4	29%	0.90	70	1.0	100	30	2,832	47	100	Max detect
RAD_D	Thorium-228	pCi/g	7	7	100%	--	--	0.0069	0.010	0.0081	0.0090	0.0089	0.0090	Lognormal
RAD_D	Tritium	pCi/g	7	6	86%	4.7	4.7	11	44	23	132	35	35	Normal
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	12	9	75%	0.34	0.35	0.017	0.073	0.069	0.14	0.10	0.073	Max detect
SVOA	Butylbenzylphthalate	mg/kg	12	2	17%	0.34	0.36	0.019	0.030	0.15	0.30	0.18	0.030	Max detect
SVOA	Diethylphthalate	mg/kg	12	2	17%	0.34	0.36	0.014	0.033	0.15	0.33	0.18	0.033	Max detect

Table C-11. Summary of Statistics for Deep Zone Soils from 216-B-45 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
SVOA	Di-n-butylphthalate	mg/kg	12	1	8%	0.34	0.35	0.031	0.031	0.16	0.23	0.18	0.031	Max detect
SVOA	Di-n-octylphthalate	mg/kg	12	5	42%	0.34	0.35	0.015	0.062	0.12	0.26	0.15	0.062	Max detect
SVOA	Dodecane	mg/kg	3	3	100%	--	--	0.20	0.47	0.31	1.9	0.55	0.47	Max detect
SVOA	Dodecane, 6-methyl-	mg/kg	2	2	100%	--	--	0.17	0.43	0.30	91	1.1	0.43	Max detect
SVOA	Hexadecane-	mg/kg	3	3	100%	--	--	0.24	0.45	0.35	0.97	0.53	0.45	Max detect
SVOA	Hexadecanoic acid (9CI)	mg/kg	3	3	100%	--	--	0.18	0.20	0.19	0.21	0.21	0.20	Max detect
SVOA	Pentadecane	mg/kg	3	3	100%	--	--	0.73	1.7	1.1	6.5	2.0	1.7	Max detect
SVOA	Phosphine oxide, triphenyl-	mg/kg	2	2	100%	--	--	0.20	0.25	0.23	0.37	0.38	0.25	Max detect
SVOA	Tetradecane	mg/kg	3	3	100%	--	--	1.0	2.2	1.4	9.7	2.6	2.2	Max detect
SVOA	Tributyl phosphate	mg/kg	6	6	100%	--	--	0.17	32	10	165,895	21	32	Max detect
SVOA	Tridecane	mg/kg	3	3	100%	--	--	0.59	1.5	0.91	11	1.8	1.5	Max detect
SVOA	Tridecane, 4-methyl	mg/kg	1	1	100%	--	--	0.15	0.15	0.15	--	--	0.15	Max detect
SVOA	Undecane, 2,6-dimethyl-	mg/kg	1	1	100%	--	--	0.20	0.20	0.20	--	--	0.20	Max detect
VOA	2-ethyl-1-hexanol	mg/kg	2	2	100%	--	--	0.20	0.21	0.21	0.23	0.24	0.21	Max detect
VOA	Acetone	mg/kg	12	2	17%	0.010	0.021	0.0070	0.0080	0.0062	0.0072	0.0071	0.0072	Lognormal
VOA	Propanoic acid, 2-methyl-	mg/kg	1	1	100%	--	--	0.010	0.010	0.010	--	--	0.010	Max detect
VOA	Toluene	mg/kg	12	4	33%	0.0050	0.0060	0.0010	0.0030	0.0025	0.0030	0.0027	0.0027	Normal

EPC = exposure point concentration.
GENCH = general chemical.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-12. Summary of Statistics for Deep Zone Soils from 216-B-47 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Complex cyanide	mg/kg	3	3	100%	--	--	5.7	247	116	8.76E+17	322	247	Max detect
GENCH	Cyanide	mg/kg	13	6	46%	0.20	1.1	0.40	249	28	724	63	249	Max detect
GENCH	Free cyanide	mg/kg	4	4	100%	--	--	1.1	2.6	1.9	4.3	2.6	2.6	Max detect
GENCH	Nitrate	mg/kg	6	6	100%	--	--	2.0	28	13	143	22	22	Normal
GENCH	Nitrite	mg/kg	6	1	17%	0.80	0.80	1.6	1.6	0.60	1.2	1.0	1.2	Lognormal
GENCH	Phosphate	mg/kg	6	6	100%	--	--	6.7	40	20	47	30	40	Max detect
GENCH	Sulfate	mg/kg	6	6	100%	--	--	38	196	92	240	145	196	Max detect
GENOR	Total organic carbon	mg/kg	6	6	100%	--	--	17	62	35	67	50	62	Max detect
METAL	Aluminum	mg/kg	12	12	100%	--	--	3,300	7,610	5,238	5,984	5,866	5,984	Lognormal
METAL	Arsenic	mg/kg	12	12	100%	--	--	1.6	3.2	2.2	2.5	2.4	2.5	Lognormal
METAL	Barium	mg/kg	12	12	100%	--	--	52	108	71	79	79	79	Lognormal
METAL	Beryllium	mg/kg	12	9	75%	0.20	0.39	0.22	0.34	0.26	0.33	0.30	0.30	Normal
METAL	Bismuth	mg/kg	6	6	100%	--	--	0.58	26	6.9	1,296	16	26	Max detect
METAL	Cadmium	mg/kg	12	8	67%	0.78	0.83	0.41	1.3	0.69	0.92	0.86	0.92	Lognormal
METAL	Calcium	mg/kg	12	12	100%	--	--	5,990	9,690	7,472	8,233	8,186	8,233	Lognormal
METAL	Chromium	mg/kg	12	12	100%	--	--	5.3	13	8.6	10	9.8	9.8	Normal
METAL	Cobalt	mg/kg	12	10	83%	10	10	3.9	8.0	6.4	7.4	7.2	7.4	Lognormal
METAL	Copper	mg/kg	12	12	100%	--	--	11	17	13	14	14	14	Lognormal
METAL	Iron	mg/kg	12	12	100%	--	--	11,800	21,500	15,283	17,145	16,987	17,145	Lognormal
METAL	Lead	mg/kg	12	12	100%	--	--	2.7	15	5.0	6.7	6.8	6.7	Lognormal
METAL	Magnesium	mg/kg	12	12	100%	--	--	2,870	44,600	7,113	10,251	13,241	10,251	Lognormal
METAL	Manganese	mg/kg	12	12	100%	--	--	220	310	251	266	265	266	Lognormal
METAL	Mercury	mg/kg	12	6	50%	0.050	0.050	0.050	0.15	0.055	0.089	0.076	0.089	Lognormal
METAL	Nickel	mg/kg	12	12	100%	--	--	6.8	131	24	46	44	46	Lognormal
METAL	Potassium	mg/kg	12	12	100%	--	--	401	11,600	1,714	2,781	3,335	2,781	Lognormal
METAL	Silver	mg/kg	12	1	8%	0.050	1.7	0.27	0.27	0.46	3.0	0.66	0.27	Max detect
METAL	Sodium	mg/kg	12	12	100%	--	--	111	1,730	727	2,132	1,047	1,730	Max detect
METAL	Thallium	mg/kg	12	3	25%	0.050	0.43	0.060	0.090	0.13	0.29	0.17	0.090	Max detect
METAL	Uranium	mg/kg	12	7	58%	0.50	8.0	1.1	341	61	69,969	117	341	Max detect
METAL	Vanadium	mg/kg	12	12	100%	--	--	17	54	30	38	36	38	Lognormal
METAL	Zinc	mg/kg	12	12	100%	--	--	25	42	31	34	33	34	Lognormal
PEST	Dichlorodiphenyltrichloroethane	mg/kg	12	1	8%	0.016	0.034	0.011	0.011	0.012	0.015	0.014	0.011	Max detect

Table C-12. Summary of Statistics for Deep Zone Soils from 216-B-47 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
RAD_D	Cesium-137	pCi/g	12	12	100%	--	--	0.59	7.79E+06	1.08E+06	1.68E+25	2.36E+06	7.79E+06	Max detect
RAD_D	Gross alpha	pCi/g	12	12	100%	--	--	4.7	9,279	1,440	1.39E+06	3,011	9,279	Max detect
RAD_D	Gross beta	pCi/g	12	12	100%	--	--	31	3.95E+07	5.13E+06	2.28E+21	1.14E+07	3.95E+07	Max detect
RAD_D	Plutonium-238	pCi/g	12	4	33%	0.020	11	23	185	32	1.25E+08	64	185	Max detect
RAD_D	Plutonium-239/240	pCi/g	6	4	67%	16	299	620	5,850	1,926	3.60E+08	3,968	5,850	Max detect
RAD_D	Potassium-40	pCi/g	6	6	100%	--	--	11	155	36	265	84	155	Max detect
RAD_D	Radium-226	pCi/g	6	5	83%	0.70	0.70	0.57	10	2.4	33	5.6	10	Max detect
RAD_D	Strontium-90	pCi/g	12	12	100%	--	--	0.17	1.07E+07	1.34E+06	5.90E+30	3.00E+06	1.07E+07	Max detect
RAD_D	Technetium-99	pCi/g	12	1	8%	0.90	70	50	50	18	1,506	28	28	Normal
RAD_D	Thorium-228	pCi/g	6	6	100%	--	--	0.0077	0.13	0.030	0.28	0.072	0.13	Max detect
RAD_D	Tritium	pCi/g	6	5	83%	4.0	4.0	3.8	28	8.8	43	17	28	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	12	7	58%	0.33	0.35	0.031	0.27	0.13	0.25	0.17	0.17	Normal
SVOA	Di-n-butylphthalate	mg/kg	12	5	42%	0.33	0.36	0.012	0.38	0.19	0.54	0.25	0.25	Normal
SVOA	Di-n-octylphthalate	mg/kg	12	6	50%	0.33	0.36	0.012	0.19	0.11	0.40	0.15	0.15	Normal
SVOA	Dodecane	mg/kg	1	1	100%	--	--	0.16	0.16	0.16	--	--	0.16	Max detect
SVOA	Hexadecanoic acid (9CI)	mg/kg	1	1	100%	--	--	0.14	0.14	0.14	--	--	0.14	Max detect
SVOA	Pentachlorophenol	mg/kg	12	2	17%	1.6	1.8	0.059	0.15	0.73	1.8	0.88	0.15	Max detect
SVOA	Pentadecane	mg/kg	1	1	100%	--	--	0.15	0.15	0.15	--	--	0.15	Max detect
SVOA	Tributyl phosphate	mg/kg	4	4	100%	--	--	0.15	1.6	0.53	420	1.4	1.6	Max detect
SVOA	Tridecane	mg/kg	1	1	100%	--	--	0.30	0.30	0.30	--	--	0.30	Max detect
VOA	1,1,1-trichloroethane	mg/kg	12	2	17%	0.0050	0.024	0.0010	0.0040	0.0042	0.0068	0.0059	0.0040	Max detect
VOA	2-ethyl-1-hexanol	mg/kg	1	1	100%	--	--	0.29	0.29	0.29	--		0.29	Max detect
VOA	Acetone	mg/kg	12	4	33%	0.010	0.035	0.011	0.023	0.011	0.017	0.014	0.017	Lognormal
VOA	Toluene	mg/kg	12	1	8%	0.0050	0.024	0.0010	0.0010	0.0044	0.0073	0.0061	0.0010	Max detect

EPC = exposure point concentration.
GENCH = general chemical.
PEST = pesticide.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-13. Summary of Statistics for Deep Zone Soils from 216-B-48 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Complex cyanide	mg/kg	3	3	100%	--	--	58	103	76	185	116	103	Max detect
GENCH	Cyanide	mg/kg	10	4	40%	1.0	1.1	1.6	104	23	5,472	46	104	Max detect
GENCH	Free cyanide	mg/kg	3	3	100%	--	--	0.90	1.7	1.2	3.1	1.9	1.7	Max detect
GENCH	Nitrate	mg/kg	5	5	100%	--	--	4.5	568	276	6.08E+07	520	520	Normal
GENCH	Nitrite	mg/kg	5	3	60%	0.80	0.80	14	18	9.9	447,316	18	18	Max detect
GENCH	Phosphate	mg/kg	5	5	100%	--	--	3.2	8.3	5.1	8.1	7.0	8.1	Lognormal
GENCH	Sulfate	mg/kg	5	5	100%	--	--	5.1	462	151	1.08E+06	330	462	Max detect
GENOR	Total organic carbon	mg/kg	5	5	100%	--	--	15	43	31	62	43	43	Max detect
METAL	Aluminum	mg/kg	10	10	100%	--	--	3,910	7,610	5,497	6,465	6,294	6,465	Lognormal
METAL	Arsenic	mg/kg	10	10	100%	--	--	1.4	3.9	2.4	2.9	2.8	2.9	Lognormal
METAL	Barium	mg/kg	10	10	100%	--	--	46	89	63	70	69	70	Lognormal
METAL	Beryllium	mg/kg	10	8	80%	0.20	0.38	0.23	0.37	0.26	0.34	0.30	0.30	Normal
METAL	Bismuth	mg/kg	5	3	60%	0.24	0.28	3.4	37	9.6	1.17E+08	24	37	Max detect
METAL	Cadmium	mg/kg	10	1	10%	0.36	1.4	0.55	0.55	0.45	0.57	0.52	0.52	Normal
METAL	Calcium	mg/kg	10	10	100%	--	--	5,000	10,300	7,506	8,532	8,358	8,358	Normal
METAL	Chromium	mg/kg	10	10	100%	--	--	5.8	14	9.2	12	11	12	Lognormal
METAL	Cobalt	mg/kg	10	9	90%	9.1	9.1	5.8	9.3	7.3	8.4	8.2	8.2	Normal
METAL	Copper	mg/kg	10	10	100%	--	--	8.7	18	13	15	15	15	Lognormal
METAL	Iron	mg/kg	10	10	100%	--	--	11,300	24,700	16,850	20,049	19,451	20,049	Lognormal
METAL	Lead	mg/kg	10	10	100%	--	--	2.8	24	6.8	11	10	11	Lognormal
METAL	Magnesium	mg/kg	10	10	100%	--	--	3,090	5,300	4,121	4,725	4,637	4,725	Lognormal
METAL	Manganese	mg/kg	10	10	100%	--	--	198	341	273	303	299	299	Normal
METAL	Mercury	mg/kg	10	6	60%	0.050	0.050	0.060	0.38	0.15	0.65	0.22	0.22	Normal
METAL	Nickel	mg/kg	10	10	100%	--	--	7.6	251	48	218	93	218	Lognormal
METAL	Potassium	mg/kg	10	6	60%	575	1,130	661	1,320	723	1,052	909	909	Normal
METAL	Selenium	mg/kg	10	1	10%	0.40	1.2	1.1	1.1	0.44	0.74	0.61	0.74	Lognormal
METAL	Sodium	mg/kg	10	10	100%	--	--	129	1,770	783	2,154	1,117	1,117	Normal
METAL	Thallium	mg/kg	10	5	50%	0.40	0.42	0.070	0.12	0.15	0.21	0.19	0.12	Max detect
METAL	Uranium	mg/kg	9	7	78%	0.50	0.60	1.3	223	54	211,935	104	223	Max detect
METAL	Vanadium	mg/kg	10	10	100%	--	--	20	62	35	45	43	45	Lognormal

Table C-13. Summary of Statistics for Deep Zone Soils from 216-B-48 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Zinc	mg/kg	10	10	100%	--	--	24	48	35	40	39	40	Lognormal
PEST	Dichlorodiphenyltrichloroethane	mg/kg	10	1	10%	0.016	0.034	0.0062	0.0062	0.011	0.015	0.014	0.0062	Max detect
RAD_D	Cesium-137	pCi/g	10	10	100%	--	--	0.14	9.84E+06	1.53E+06	1.02E+35	3.34E+06	9.8E+06	Max detect
RAD_D	Cobalt-60	pCi/g	10	2	20%	0.020	830	0.017	13	53	4.69E+09	130	13	Max detect
RAD_D	Gross alpha	pCi/g	10	9	90%	3.0	3.0	4.7	5,995	980	1.00E+07	2,108	5,995	Max detect
RAD_D	Gross beta	pCi/g	10	10	100%	--	--	33	2.97E+07	6.00E+06	1.23E+25	1.20E+07	2.97E+07	Max detect
RAD_D	Plutonium-238	pCi/g	10	4	40%	0.010	0.070	0.51	59	9.2	1.10E+07	21	59	Max detect
RAD_D	Plutonium-239/240	pCi/g	5	5	100%	--	--	0.070	1,200	388	1.64E+20	897	1,200	Max detect
RAD_D	Potassium-40	pCi/g	5	5	100%	--	--	10	17	14	16	16	16	Normal
RAD_D	Radium-226	pCi/g	5	3	60%	0.50	3.0	0.65	1.6	1.0	5.5	1.6	1.6	Max detect
RAD_D	Strontium-90	pCi/g	10	10	100%	--	--	0.21	8.04E+06	1.65E+06	6.82E+32	3.30E+06	8.04E+06	Max detect
RAD_D	Technetium-99	pCi/g	10	2	20%	0.90	70	90	200	39	29,150	76	200	Max detect
RAD_D	Thorium-228	pCi/g	5	5	100%	--	--	0.0074	0.012	0.010	0.013	0.012	0.012	Normal
RAD_D	Tritium	pCi/g	5	5	100%	--	--	7.6	23	13	27	19	23	Max detect
SVOA	2,6-dibromo-4-nitrophenol	mg/kg	2	2	100%	--	--	0.28	0.31	0.30	0.36	0.39	0.31	Max detect
SVOA	2-fluoro-4-nitrophenol	mg/kg	3	3	100%	--	--	0.22	0.41	0.32	0.83	0.48	0.41	Max detect
SVOA	Benzothiazole	mg/kg	1	1	100%	--	--	0.27	0.27	0.27	--		0.27	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	10	3	30%	0.084	0.56	0.019	0.28	0.15	0.44	0.21	0.21	Normal
SVOA	Di-n-butylphthalate	mg/kg	10	1	10%	0.33	0.35	0.086	0.086	0.16	0.19	0.18	0.086	Max detect
SVOA	Di-n-octylphthalate	mg/kg	10	1	10%	0.33	0.35	0.029	0.029	0.16	0.26	0.18	0.029	Max detect
SVOA	Dodecane	mg/kg	1	1	100%	--	--	0.41	0.41	0.41	--	--	0.41	Max detect
SVOA	Heptadecane	mg/kg	1	1	100%	--	--	0.15	0.15	0.15	--	--	0.15	Max detect
SVOA	Hexadecane-	mg/kg	1	1	100%	--	--	0.33	0.33	0.33	--	--	0.33	Max detect
SVOA	Hexadecanoic acid (9CI)	mg/kg	2	2	100%	--	--	0.19	0.28	0.24	0.70	0.52	0.28	Max detect
SVOA	Pentadecane	mg/kg	1	1	100%	--	--	0.88	0.88	0.88	--	--	0.88	Max detect
SVOA	Phosphoric acid, dibutyl 3-hydroxybutyl ester	mg/kg	1	1	100%	--	--	0.34	0.34	0.34	--	--	0.34	Max detect
SVOA	Tetradecane	mg/kg	1	1	100%	--	--	1.2	1.2	1.2	--		1.2	Max detect
SVOA	Tributyl phosphate	mg/kg	3	3	100%	--	--	1.9	11	5.6	8,637	14	11	Max detect
SVOA	Tridecane	mg/kg	1	1	100%	--	--	0.97	0.97	0.97	--	--	0.97	Max detect

Table C-13. Summary of Statistics for Deep Zone Soils from 216-B-48 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
VOA	Methylene chloride	mg/kg	9	1	11%	0.0050	0.0070	0.0020	0.0020	0.0028	0.0032	0.0031	0.0020	Max detect
VOA	Propanoic acid, 2-methyl-	mg/kg	3	3	100%	--	--	0.012	0.20	0.12	5.83E+08	0.28	0.20	Max detect
VOA	Toluene	mg/kg	9	1	11%	0.0050	0.0060	0.0010	0.0010	0.0024	0.0031	0.0027	0.0010	Max detect

EPC = exposure point concentration.
GENCH = general chemical.
PEST = pesticide.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-14. Summary of Statistics for Deep Zone Soils from 216-B-49 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
GENCH	Complex cyanide	mg/kg	1	1	100%	--	--	21	21	21	--	--	21	Max detect
GENCH	Cyanide	mg/kg	17	3	18%	1.0	1.1	1.5	21	1.9	2.4	4.0	2.4	Lognormal
GENCH	Free cyanide	mg/kg	1	1	100%	--	--	0.19	0.19	0.19	--	--	0.19	Max detect
GENCH	Sulfate	mg/kg	1	1	100%	--	--	92	92	92	--	--	92	Max detect
GENOR	Total organic carbon	mg/kg	1	1	100%	--	--	40	40	40	--	--	40	Max detect
METAL	Aluminum	mg/kg	17	17	100%	--	--	2,470	9,400	3,937	4,683	4,705	4,683	Lognormal
METAL	Arsenic	mg/kg	17	17	100%	--	--	0.61	4.1	1.8	2.3	2.2	2.3	Lognormal
METAL	Barium	mg/kg	17	16	94%	90	90	36	107	55	63	63	63	Lognormal
METAL	Beryllium	mg/kg	17	15	88%	0.19	0.19	0.23	0.50	0.29	0.37	0.34	0.34	Normal
METAL	Bismuth	mg/kg	1	1	100%	--	--	6.3	6.3	6.3	--	--	6.3	Max detect
METAL	Cadmium	mg/kg	17	2	12%	0.38	0.80	0.41	0.89	0.34	0.39	0.41	0.39	Lognormal
METAL	Calcium	mg/kg	17	17	100%	--	--	3,640	10,400	6,098	7,005	6,868	7,005	Lognormal
METAL	Chromium	mg/kg	17	17	100%	--	--	3.3	13	7.0	9.1	8.5	9.1	Lognormal
METAL	Cobalt	mg/kg	17	17	100%	--	--	3.4	11	6.0	7.1	7.0	7.1	Lognormal
METAL	Copper	mg/kg	17	16	94%	13	13	6.8	77	14	18	21	18	Lognormal

Table C-14. Summary of Statistics for Deep Zone Soils from 216-B-49 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Iron	mg/kg	17	17	100%	--	--	6,190	23,400	10,943	13,269	13,115	13,269	Lognormal
METAL	Lead	mg/kg	17	17	100%	--	--	1.4	16	4 8	6.7	6.4	6.7	Lognormal
METAL	Magnesium	mg/kg	17	17	100%	--	--	1,660	5,320	2,874	3,380	3,342	3,380	Lognormal
METAL	Manganese	mg/kg	17	17	100%	--	--	129	353	213	247	243	247	Lognormal
METAL	Mercury	mg/kg	16	5	31%	0.050	0.10	0 080	0.38	0.089	0.17	0.14	0.17	Lognormal
METAL	Nickel	mg/kg	17	17	100%	--	--	4.5	46	10	13	14	13	Lognormal
METAL	Potassium	mg/kg	17	16	94%	677	677	476	1,860	872	1,055	1,018	1,055	Lognormal
METAL	Selenium	mg/kg	17	1	6%	0.34	0.42	0.46	0 46	0.21	0.23	0.24	0.23	Lognormal
METAL	Silver	mg/kg	15	2	13%	0.040	2.1	1.5	1.8	0.93	2 8	1.1	1.1	Normal
METAL	Sodium	mg/kg	17	17	100%	--	--	108	4,360	1,288	3,611	1,781	3,611	Lognormal
METAL	Thallium	mg/kg	17	2	12%	0.37	0.42	0 080	0.40	0 20	0.23	0.23	0.23	Lognormal
METAL	Uranium	mg/kg	18	5	28%	0 40	1.4	2.4	121	10	40	22	40	Lognormal
METAL	Vanadium	mg/kg	17	17	100%	--	--	8.1	57	20	26	25	26	Lognormal
METAL	Zinc	mg/kg	17	17	100%	--	--	17	52	27	32	32	32	Lognormal
RAD_D	Cesium-137	pCi/g	19	12	63%	0 020	1.6	0 060	1.25E+06	115.635	1.02E+14	253,931	1.25E+06	Max detect
RAD_D	Cobalt-60	pCi/g	19	11	58%	0 020	50	0.034	0 80	2 0	29	4.4	0.80	Max detect
RAD_D	Gross alpha	pCi/g	19	17	89%	5.9	6.4	2.1	860	97	231	200	231	Lognormal
RAD_D	Gross beta	pCi/g	19	15	79%	27	62	32	6 63E+06	611,609	1.19E+09	1.34E+06	6 63E+06	Max detect
RAD_D	Plutonium-238	pCi/g	19	2	11%	0.0090	0 43	9 8	10	1.1	5.5	2.3	5.5	Lognormal
RAD_D	Plutonium-239	pCi/g	16	2	13%	0.010	0 010	0.090	0.11	0 017	0 025	0 031	0.031	Normal
RAD_D	Plutonium-239/240	pCi/g	3	2	67%	32	32	556	588	387	1.53E+20	928	588	Max detect
RAD_D	Potassium-40	pCi/g	16	16	100%	--	--	10	17	13	14	14	14	Normal
RAD_D	Radium-226	pCi/g	16	12	75%	0.50	2 0	0 60	3.7	1.2	1.9	1.6	1.9	Lognormal
RAD_D	Strontium-90	pCi/g	19	11	58%	0 050	15	0.045	1.56E+06	160.860	4.01E+13	349,477	1.56E+06	Max detect
RAD_D	Technetium-99	pCi/g	16	8	50%	0 80	340	13	160	64	4,091	91	91	Normal
RAD_D	Thorium-228	pCi/g	16	15	94%	0 62	0 62	0 0058	0.014	0.027	0.029	0.060	0 014	Max detect
RAD_D	Tritium	pCi/g	3	3	100%	--	--	4.0	19	9.9	4,813	24	19	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	11	4	36%	0.34	0.34	0.068	0.10	0.14	0.18	0.16	0.10	Max detect
SVOA	Di-n-butylphthalate	mg/kg	11	4	36%	0.34	0 82	0.073	3.1	0.84	3.9	1.5	3.1	Max detect
SVOA	Di-n-octylphthalate	mg/kg	11	1	9%	0.34	0.36	0.13	0.13	0.17	0.18	0.17	0.13	Max detect
SVOA	Phosphine oxide, triphenyl-	mg/kg	1	1	100%	--	--	0 25	0.25	0.25	--	--	0.25	Max detect
SVOA	Tributyl phosphate	mg/kg	1	1	100%	--	--	0.28	0.28	0.28	--	--	0.28	Max detect

Table C-14. Summary of Statistics for Deep Zone Soils from 216-B-49 Crib, Human Health Risk Assessment. (3 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
VOA	2-butanone	mg/kg	11	1	9%	0.010	0.011	0.0090	0.0090	0.0054	0.0060	0.0061	0.0060	Lognormal
VOA	Acetone	mg/kg	12	3	25%	0.010	0.034	0.011	0.059	0.014	0.024	0.022	0.024	Lognormal
VOA	Methylene chloride	mg/kg	12	2	17%	0.0050	0.052	0.023	0.026	0.0097	0.022	0.015	0.022	Lognormal

EPC = exposure point concentration.
GENCH = general chemical.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-15. Summary of Statistics for Deep Zone Soils from 216-B-50 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Aluminum	mg/kg	8	8	100%	--	--	2,140	4,630	3,754	4,667	4,343	4,343	Normal
METAL	Arsenic	mg/kg	8	8	100%	--	--	0.82	1.8	1.4	1.8	1.7	1.7	Normal
METAL	Barium	mg/kg	8	8	100%	--	--	40	66	58	67	65	65	Normal
METAL	Beryllium	mg/kg	8	8	100%	--	--	0.24	0.44	0.32	0.38	0.37	0.38	Lognormal
METAL	Cadmium	mg/kg	8	1	13%	0.56	0.61	0.88	0.88	0.37	0.50	0.51	0.50	Lognormal
METAL	Calcium	mg/kg	8	8	100%	--	--	5,440	7,850	6,520	7,217	7,148	7,217	Lognormal
METAL	Chromium	mg/kg	8	8	100%	--	--	3.4	8.4	5.4	6.9	6.5	6.9	Lognormal
METAL	Cobalt	mg/kg	8	8	100%	--	--	4.1	7.8	6.4	7.6	7.3	7.3	Normal
METAL	Copper	mg/kg	8	8	100%	--	--	8.8	12	10	11	11	11	Lognormal
METAL	Iron	mg/kg	8	8	100%	--	--	6,130	14,500	11,398	14,759	13,441	13,441	Normal
METAL	Lead	mg/kg	8	8	100%	--	--	2.1	4.2	3.2	4.0	3.8	3.8	Normal
METAL	Magnesium	mg/kg	8	8	100%	--	--	1,780	5,300	3,096	4,073	3,810	4,073	Lognormal
METAL	Manganese	mg/kg	8	8	100%	--	--	146	283	225	269	257	257	Normal
METAL	Mercury	mg/kg	8	3	38%	0.050	0.10	0.080	0.20	0.066	0.17	0.11	0.17	Lognormal
METAL	Nickel	mg/kg	8	8	100%	--	--	5.2	27	9.1	14	14	14	Lognormal
METAL	Potassium	mg/kg	8	6	75%	905	1,000	450	1,150	717	1,013	912	1,013	Lognormal
METAL	Silver	mg/kg	8	1	13%	1.9	2.0	1.4	1.4	1.0	1.1	1.1	1.1	Lognormal
METAL	Sodium	mg/kg	8	8	100%	--	--	146	1,080	481	1,339	747	1,080	Max detect

Table C-15. Summary of Statistics for Deep Zone Soils from 216-B-50 Crib, Human Health Risk Assessment. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95% UCL Lognormal Result	95% UCL Normal Result	EPC	EPC Basis
METAL	Uranium	mg/kg	9	1	11%	0.30	10	23	23	3.3	47	7.9	23	Max detect
METAL	Vanadium	mg/kg	8	8	100%	--	--	9.1	27	19	27	23	23	Normal
METAL	Zinc	mg/kg	8	8	100%	--	--	15	32	24	29	28	28	Normal
RAD_D	Cesium-137	pCi/g	11	11	100%	--	--	0.38	1.51E+06	215,253	3.13E+24	467,853	1.51E+06	Max detect
RAD_D	Cobalt-60	pCi/g	11	2	18%	0.010	30	0.016	5.8	2.3	6,520	4.8	5.8	Max detect
RAD_D	Gross alpha	pCi/g	11	9	82%	4.0	5.0	0.92	333	46	534	101	333	Max detect
RAD_D	Gross beta	pCi/g	11	11	100%	--	--	12	2.98E+06	333,584	2.52E+14	823,700	2.98E+06	Max detect
RAD_D	Plutonium-238	pCi/g	11	2	18%	0.010	1.9	0.0091	4.6	0.51	25	1.3	4.6	Max detect
RAD_D	Plutonium-239	pCi/g	8	1	13%	0.010	0.020	0.24	0.24	0.035	0.22	0.091	0.22	Lognormal
RAD_D	Plutonium-239/240	pCi/g	3	1	33%	3.0	121	249	249	104	1.27E+31	322	249	Max detect
RAD_D	Potassium-40	pCi/g	8	8	100%	--	--	10.0	15	12	14	13	13	Normal
RAD_D	Radium-226	pCi/g	8	4	50%	0.60	20	0.64	1.1	1.8	7.5	4.1	1.1	Max detect
RAD_D	Strontium-90	pCi/g	11	7	64%	0.10	250	0.097	425,000	43,745	1.31E+21	113,312	425,000	Max detect
RAD_D	Technetium-99	pCi/g	11	2	18%	0.70	340	1.7	132	29	3,350	63	132	Max detect
RAD_D	Thorium-228	pCi/g	8	7	88%	1.0	1.0	0.0062	0.0087	0.069	0.60	0.19	0.0087	Max detect
RAD_D	Tritium	pCi/g	3	1	33%	16	56	16	16	17	702	34	16	Max detect
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	2	1	50%	0.35	0.35	0.038	0.038	0.11	597,010	0.54	0.038	Max detect
SVOA	Di-n-butylphthalate	mg/kg	3	1	33%	0.35	0.35	0.082	0.082	0.14	0.87	0.23	0.082	Max detect
VOA	Acetone	mg/kg	2	1	50%	0.027	0.027	0.087	0.087	0.050	5.75E+08	0.28	0.087	Max detect
VOA	Methylene chloride	mg/kg	2	1	50%	0.013	0.013	0.032	0.032	0.019	434,706	0.100	0.032	Max detect

EPC = exposure point concentration.
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
UCL = upper confidence limit.
VOA = volatile organic analyte.

Table C-16. Comparison of Maximum Detected Values in Shallow Zone Soils from 216-B-43 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	4,530	11,800	No
METAL	Arsenic	mg/kg	2.3	6.5	No
METAL	Barium	mg/kg	101	132	No
METAL	Beryllium	mg/kg	0.42	1.5	No
METAL	Chromium	mg/kg	7.1	19	No
METAL	Cobalt	mg/kg	8.8	16	No
METAL	Copper	mg/kg	16	22	No
METAL	Lead	mg/kg	4.9	10	No
METAL	Manganese	mg/kg	264	512	No
METAL	Nickel	mg/kg	8.3	19	No
METAL	Silver	mg/kg	2.5	0.73	Yes
METAL	Vanadium	mg/kg	29	85	No
METAL	Zinc	mg/kg	32	68	No
RAD_D	Cesium-137	pCi/g	2.8	1.1	Yes
RAD_D	Plutonium-238	pCi/g	0.036	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.020	NA	NA
RAD_D	Potassium-40	pCi/g	13	17	No
RAD_D	Radium-226	pCi/g	1.3	0.82	Yes
RAD_D	Strontium-90	pCi/g	2.8	0.18	Yes
RAD_D	Technetium-99	pCi/g	1.1	NA	NA
RAD_D	Thorium-228	pCi/g	0.0088	1.3	No

NA = not available.
RAD_D = *decayed radiological.*

Table C-17. Comparison of Maximum Detected Values In Shallow Zone Soils from 216-B-44 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	5,680	11,800	No
METAL	Arsenic	mg/kg	2.2	6.5	No
METAL	Barium	mg/kg	80	132	No
METAL	Beryllium	mg/kg	0.45	1.5	No
METAL	Chromium	mg/kg	7.4	19	No
METAL	Cobalt	mg/kg	10	16	No
METAL	Copper	mg/kg	14	22	No
METAL	Lead	mg/kg	5.3	10	No
METAL	Manganese	mg/kg	310	512	No
METAL	Nickel	mg/kg	9.0	19	No
METAL	Silver	mg/kg	2.4	0.73	Yes
METAL	Uranium	mg/kg	1.5	3.2	No
METAL	Vanadium	mg/kg	28	85	No
METAL	Zinc	mg/kg	34	68	No
RAD_D	Cesium-137	pCi/g	3.7	1.1	Yes
RAD_D	Plutonium-239	pCi/g	0.010	NA	NA
RAD_D	Potassium-40	pCi/g	13	17	No
RAD_D	Radium-226	pCi/g	1.3	0.82	Yes
RAD_D	Strontium-90	pCi/g	1.7	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.010	1.3	No

NA = not available.
RAD_D = decayed radiological.

Table C-18. Comparison of Maximum Detected Values in Shallow Zone Soils from 216-B-45 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate	mg/kg	5.9	52	No
METAL	Aluminum	mg/kg	7,130	11,800	No
METAL	Arsenic	mg/kg	2.2	6.5	No
METAL	Barium	mg/kg	77	132	No
METAL	Beryllium	mg/kg	0.73	1.5	No
METAL	Cadmium	mg/kg	1.3	1.0	Yes
METAL	Chromium	mg/kg	12	19	No
METAL	Cobalt	mg/kg	13	16	No
METAL	Copper	mg/kg	15	22	No
METAL	Lead	mg/kg	28	10	Yes
METAL	Manganese	mg/kg	368	512	No
METAL	Nickel	mg/kg	12	19	No
METAL	Silver	mg/kg	1.7	0.73	Yes
METAL	Thallium	mg/kg	0.11	NA	NA
METAL	Vanadium	mg/kg	47	85	No
METAL	Zinc	mg/kg	46	68	No
RAD_D	Cesium-137	pCi/g	2.5	1.1	Yes
RAD_D	Plutonium-239	pCi/g	0.010	NA	NA
RAD_D	Potassium-40	pCi/g	13	17	No
RAD_D	Radium-226	pCi/g	0.82	0.82	Yes
RAD_D	Strontium-90	pCi/g	1.3	0.18	Yes
RAD_D	Technetium-99	pCi/g	1.0	NA	NA
RAD_D	Thorium-228	pCi/g	0.0086	1.3	No

GENCH = general chemical.
NA = not available.
RAD_D = decayed radiological.

Table C-19. Comparison of Maximum Detected Values in Shallow Zone Soils from 216-B-47 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	4,850	11,800	No
METAL	Arsenic	mg/kg	2.6	6.5	No
METAL	Barium	mg/kg	77	132	No
METAL	Beryllium	mg/kg	0.30	1.5	No
METAL	Cadmium	mg/kg	1.3	1.0	Yes
METAL	Chromium	mg/kg	9.6	19	No
METAL	Cobalt	mg/kg	8.0	16	No
METAL	Copper	mg/kg	13	22	No
METAL	Lead	mg/kg	5.8	10	No
METAL	Manganese	mg/kg	282	512	No
METAL	Nickel	mg/kg	14	19	No
METAL	Uranium	mg/kg	1.1	3.2	No
METAL	Vanadium	mg/kg	29	85	No
METAL	Zinc	mg/kg	32	68	No
RAD_D	Cesium-137	pCi/g	53	1.1	Yes
RAD_D	Potassium-40	pCi/g	155	17	Yes
RAD_D	Radium-226	pCi/g	10	0.82	Yes
RAD_D	Strontium-90	pCi/g	6.9	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.13	1.3	No

RAD_D = decayed radiological.

Table C-20. Comparison of Maximum Detected Values for Shallow Zone Soils from 216-B-48 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	6,590	11,800	No
METAL	Arsenic	mg/kg	2.1	6.5	No
METAL	Barium	mg/kg	86	132	No
METAL	Beryllium	mg/kg	0.44	1.5	No
METAL	Chromium	mg/kg	9.8	19	No
METAL	Cobalt	mg/kg	11	16	No
METAL	Copper	mg/kg	12	22	No
METAL	Lead	mg/kg	5.4	10	No
METAL	Manganese	mg/kg	325	512	No
METAL	Nickel	mg/kg	17	19	No
METAL	Uranium	mg/kg	2.5	3.2	No
METAL	Vanadium	mg/kg	40	85	No
METAL	Zinc	mg/kg	38	68	No
RAD_D	Cesium-137	pCi/g	2.8	1.1	Yes
RAD_D	Potassium-40	pCi/g	16	17	No
RAD_D	Radium-226	pCi/g	1.6	0.82	Yes
RAD_D	Strontium-90	pCi/g	9.8	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.013	13	No

RAD_D = decayed radiological.

Table C-21. Comparison of Maximum Detected Values in Shallow Zone Soils from 216-B-49 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	5,600	11,800	No
METAL	Arsenic	mg/kg	4.1	6.5	No
METAL	Barium	mg/kg	66	132	No
METAL	Beryllium	mg/kg	0.44	1.5	No
METAL	Cadmium	mg/kg	0.89	1.0	No
METAL	Chromium	mg/kg	12	19	No
METAL	Cobalt	mg/kg	11	16	No
METAL	Copper	mg/kg	77	22	Yes
METAL	Lead	mg/kg	7.7	10	No
METAL	Manganese	mg/kg	312	512	No
METAL	Nickel	mg/kg	11	19	No
METAL	Silver	mg/kg	1.8	0.73	Yes
METAL	Vanadium	mg/kg	43	85	No
METAL	Zinc	mg/kg	38	68	No
RAD_D	Cesium-137	pCi/g	1.5	1.1	Yes
RAD_D	Potassium-40	pCi/g	14	17	No
RAD_D	Radium-226	pCi/g	0.76	0.82	No
RAD_D	Strontium-90	pCi/g	8.1	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.0071	1.3	No

RAD_D = decayed radiological.

Table C-22. Comparison of Maximum Detected Values in Shallow Zone Soils from 216-B-50 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	4,630	11,800	No
METAL	Arsenic	mg/kg	1.8	6.5	No
METAL	Barium	mg/kg	71	132	No
METAL	Beryllium	mg/kg	0.44	1.5	No
METAL	Chromium	mg/kg	6.8	19	No
METAL	Cobalt	mg/kg	7.7	16	No
METAL	Copper	mg/kg	12	22	No
METAL	Lead	mg/kg	4.6	10	No
METAL	Manganese	mg/kg	283	512	No
METAL	Nickel	mg/kg	9.0	19	No
METAL	Uranium	mg/kg	1.6	3.2	No
METAL	Vanadium	mg/kg	27	85	No
METAL	Zinc	mg/kg	32	68	No
RAD_D	Cesium-137	pCi/g	3.7	1.1	Yes
RAD_D	Plutonium-238	pCi/g	0.0091	0.0038	Yes
RAD_D	Potassium-40	pCi/g	13	17	No
RAD_D	Radium-226	pCi/g	1.1	0.82	Yes
RAD_D	Strontium-90	pCi/g	0.24	0.18	Yes
RAD_D	Technetium-99	pCi/g	1.7	NA	NA
RAD_D	Thorium-228	pCi/g	0.0087	1.3	No

NA = not available.
RAD_D = decayed radiological.

Table C-23. Comparison of Maximum Detected Values in Deep Zone Soils from 216-B-43 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate (as nitrogen)	mg/kg	565	12	Yes
METAL	Aluminum	mg/kg	10,300	11,800	No
METAL	Arsenic	mg/kg	2.9	6.5	No
METAL	Antimony	mg/kg	5.8	NA	NA
METAL	Barium	mg/kg	101	132	No
METAL	Beryllium	mg/kg	0.42	1.5	No
METAL	Cadmium	mg/kg	1.8	1.0	Yes
METAL	Chromium	mg/kg	119	19	Yes
METAL	Cobalt	mg/kg	8.8	16	No
METAL	Copper	mg/kg	19	22	No
METAL	Lead	mg/kg	6.2	10	No
METAL	Manganese	mg/kg	294	512	No
METAL	Mercury	mg/kg	0.18	0.33	No
METAL	Nickel	mg/kg	67	19	Yes
METAL	Silver	mg/kg	2.5	0.73	Yes
METAL	Thallium	mg/kg	0.11	NA	NA
METAL	Uranium	mg/kg	31	3.2	Yes
METAL	Vanadium	mg/kg	50	85	No
METAL	Zinc	mg/kg	37	68	No
RAD_D	Cesium-134	pCi/g	8.87E-04	NA	NA
RAD_D	Cesium-137	pCi/g	2.60E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	0.42	NA	NA
RAD_D	Plutonium-238	pCi/g	7.8	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.020	NA	NA
RAD_D	Plutonium-239/240	pCi/g	405	0.025	Yes
RAD_D	Potassium-40	pCi/g	17	17	Yes
RAD_D	Radium-226	pCi/g	1.3	0.82	Yes
RAD_D	Strontium-90	pCi/g	5.00E+06	0.18	Yes
RAD_D	Technetium-99	pCi/g	210	NA	NA
RAD_D	Thorium-228	pCi/g	0.012	1.3	No
RAD_D	Tritium	pCi/g	100	NA	NA

GENCH = general chemical.
NA = not available.
RAD_D = decayed radiological.

Table C-24. Comparison of Maximum Detected Values In Deep Zone Soils from 216-B-44 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate (as nitrogen)	mg/kg	1,040	12	Yes
METAL	Aluminum	mg/kg	8,010	11,800	No
METAL	Arsenic	mg/kg	5.1	6.5	No
METAL	Barium	mg/kg	80	132	No
METAL	Beryllium	mg/kg	0.45	1.5	No
METAL	Cadmium	mg/kg	0.69	1.0	No
METAL	Chromium	mg/kg	13	19	No
METAL	Cobalt	mg/kg	10	16	No
METAL	Copper	mg/kg	18	22	No
METAL	Lead	mg/kg	11	10	Yes
METAL	Manganese	mg/kg	325	512	No
METAL	Mercury	mg/kg	0.14	0.33	No
METAL	Nickel	mg/kg	94	19	Yes
METAL	Silver	mg/kg	2.4	0.73	Yes
METAL	Thallium	mg/kg	0.10	NA	NA
METAL	Uranium	mg/kg	95	3.2	Yes
METAL	Vanadium	mg/kg	68	85	No
METAL	Zinc	mg/kg	53	68	No
RAD_D	Cesium-137	pCi/g	2.20E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	11	NA	NA
RAD_D	Plutonium-238	pCi/g	51	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.010	NA	NA
RAD_D	Plutonium-239/240	pCi/g	626	0.025	Yes
RAD_D	Potassium-40	pCi/g	13	17	No
RAD_D	Radium-226	pCi/g	1.3	0.82	Yes
RAD_D	Strontium-90	pCi/g	4.92E+06	0.18	Yes
RAD_D	Technetium-99	pCi/g	200	NA	NA
RAD_D	Thorium-228	pCi/g	0.010	1.3	No
RAD_D	Tritium	pCi/g	20	NA	NA

GENCH = general chemical.
NA = not available.
RAD_D = decayed radiological.

Table C-25. Comparison of Maximum Detected Values in Deep Zone Soils from 216-B-45 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate (as nitrogen)	mg/kg	681	12	Yes
METAL	Aluminum	mg/kg	15,800	11,800	Yes
METAL	Arsenic	mg/kg	3.2	6.5	No
METAL	Barium	mg/kg	129	132	No
METAL	Beryllium	mg/kg	0.73	1.5	No
METAL	Cadmium	mg/kg	2.7	1.0	Yes
METAL	Chromium	mg/kg	17	19	No
METAL	Cobalt	mg/kg	13	16	No
METAL	Copper	mg/kg	24	22	Yes
METAL	Lead	mg/kg	28	10	Yes
METAL	Manganese	mg/kg	464	512	No
METAL	Mercury	mg/kg	0.34	0.33	Yes
METAL	Nickel	mg/kg	135	19	Yes
METAL	Silver	mg/kg	1.7	0.73	Yes
METAL	Thallium	mg/kg	0.14	NA	NA
METAL	Uranium	mg/kg	55	3.2	Yes
METAL	Vanadium	mg/kg	100	85	Yes
METAL	Zinc	mg/kg	60	68	No
RAD_D	Cesium-137	pCi/g	4.83E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	0.57	NA	NA
RAD_D	Plutonium-238	pCi/g	104	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.12	NA	NA
RAD_D	Plutonium-239/240	pCi/g	2,350	0.025	Yes
RAD_D	Potassium-40	pCi/g	16	17	No
RAD_D	Radium-226	pCi/g	1.8	0.82	Yes
RAD_D	Strontium-90	pCi/g	4.46E+06	0.18	Yes
RAD_D	Technetium-99	pCi/g	100	NA	NA
RAD_D	Thorium-228	pCi/g	0.010	1.3	No
RAD_D	Tritium	pCi/g	44	NA	NA

GENCH = general chemical.
NA = not available.
RAD_D = decayed radiological.

Table C-26. Comparison of Maximum Detected Values in Deep Zone Soils from 216-B-47 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate (as nitrogen)	mg/kg	28	12	Yes
METAL	Aluminum	mg/kg	7,610	11,800	No
METAL	Arsenic	mg/kg	3.2	6.5	No
METAL	Barium	mg/kg	108	132	No
METAL	Beryllium	mg/kg	0.34	1.5	No
METAL	Cadmium	mg/kg	1.3	1.0	Yes
METAL	Chromium	mg/kg	13	19	No
METAL	Cobalt	mg/kg	8.0	16	No
METAL	Copper	mg/kg	17	22	No
METAL	Lead	mg/kg	15	10	Yes
METAL	Manganese	mg/kg	310	512	No
METAL	Mercury	mg/kg	0.15	0.33	No
METAL	Nickel	mg/kg	131	19	Yes
METAL	Silver	mg/kg	0.27	0.73	No
METAL	Thallium	mg/kg	0.090	NA	NA
METAL	Uranium	mg/kg	341	3.2	Yes
METAL	Vanadium	mg/kg	54	85	No
METAL	Zinc	mg/kg	42	68	No
RAD_D	Cesium-137	pCi/g	7.79E+06	1.1	Yes
RAD_D	Plutonium-238	pCi/g	185	0.0038	Yes
RAD_D	Plutonium-239/240	pCi/g	5,850	0.025	Yes
RAD_D	Potassium-40	pCi/g	155	17	Yes
RAD_D	Radium-226	pCi/g	10	0.82	Yes
RAD_D	Strontium-90	pCi/g	1.07E+07	0.18	Yes
RAD_D	Technetium-99	pCi/g	50	NA	NA
RAD_D	Thorium-228	pCi/g	0.13	1.3	No
RAD_D	Tritium	pCi/g	28	NA	NA

GENCH = general chemical.
NA = not available.
RAD_D = decayed radiological.

Table C-27. Comparison of Maximum Detected Values in Deep Zone Soils from 216-B-48 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
GENCH	Nitrate (as nitrogen)	mg/kg	568	12	Yes
METAL	Aluminum	mg/kg	7,610	11,800	No
METAL	Arsenic	mg/kg	3.9	6.5	No
METAL	Barium	mg/kg	89	132	No
METAL	Beryllium	mg/kg	0.37	1.5	No
METAL	Cadmium	mg/kg	0.55	1.0	No
METAL	Chromium	mg/kg	14	19	No
METAL	Cobalt	mg/kg	9.3	16	No
METAL	Copper	mg/kg	18	22	No
METAL	Lead	mg/kg	24	10	Yes
METAL	Manganese	mg/kg	341	512	No
METAL	Mercury	mg/kg	0.38	0.33	Yes
METAL	Nickel	mg/kg	251	19	Yes
METAL	Selenium	mg/kg	1.1	NA	NA
METAL	Thallium	mg/kg	0.12	NA	NA
METAL	Uranium	mg/kg	233	3.2	Yes
METAL	Vanadium	mg/kg	62	85	No
METAL	Zinc	mg/kg	48	68	No
RAD_D	Cesium-137	pCi/g	9.84E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	13	NA	NA
RAD_D	Plutonium-238	pCi/g	59	0.0038	Yes
RAD_D	Plutonium-239/240	pCi/g	1,200	0.025	Yes
RAD_D	Potassium-40	pCi/g	17	17	No
RAD_D	Radium-226	pCi/g	1.6	0.82	Yes
RAD_D	Strontium-90	pCi/g	8.04E+06	0.18	Yes
RAD_D	Technetium-99	pCi/g	200	NA	NA
RAD_D	Thorium-228	pCi/g	0.012	1.3	No
RAD_D	Tritium	pCi/g	23	NA	NA

NA = not available.
RAD_D = decayed radiological.

Table C-28. Comparison of Maximum Detected Values in Deep Zone Soil Samples from 216-B-49 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	9,400	11,800	No
METAL	Arsenic	mg/kg	4.1	6.5	No
METAL	Barium	mg/kg	107	132	No
METAL	Beryllium	mg/kg	0.50	1.5	No
METAL	Cadmium	mg/kg	0.89	1.0	No
METAL	Chromium	mg/kg	13	19	No
METAL	Cobalt	mg/kg	11	16	No
METAL	Copper	mg/kg	77	22	Yes
METAL	Lead	mg/kg	16	10	Yes
METAL	Manganese	mg/kg	353	512	No
METAL	Mercury	mg/kg	0.38	0.33	Yes
METAL	Nickel	mg/kg	46	19	Yes
METAL	Selenium	mg/kg	0.46	NA	NA
METAL	Silver	mg/kg	1.8	0.73	Yes
METAL	Thallium	mg/kg	0.40	NA	NA
METAL	Uranium	mg/kg	121	3.2	Yes
METAL	Vanadium	mg/kg	57	85	No
METAL	Zinc	mg/kg	52	68	No
RAD_D	Cesium-137	pCi/g	1.25E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	0.80	NA	NA
RAD_D	Plutonium-238	pCi/g	10	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.11	NA	NA
RAD_D	Plutonium-239/240	pCi/g	588	0.025	Yes
RAD_D	Potassium-40	pCi/g	17	17	No
RAD_D	Radium-226	pCi/g	3.7	0.82	Yes
RAD_D	Strontium-90	pCi/g	1.56E+06	0.18	Yes
RAD_D	Technetium-99	pCi/g	160	NA	NA
RAD_D	Thorium-228	pCi/g	0.014	1.3	No
RAD_D	Tritium	pCi/g	19	NA	NA

NA = not available.
RAD_D = decayed radiological.

Table C-29. Comparison of Maximum Detected Values in Deep Zone Soils from 216-B-50 Crib to Background Concentrations, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Aluminum	mg/kg	4,630	11,800	No
METAL	Arsenic	mg/kg	1.8	6.5	No
METAL	Barium	mg/kg	66	132	No
METAL	Beryllium	mg/kg	0.44	1.5	No
METAL	Cadmium	mg/kg	0.88	1.0	No
METAL	Chromium	mg/kg	8.4	19	No
METAL	Cobalt	mg/kg	7.8	16	No
METAL	Copper	mg/kg	12	22	No
METAL	Lead	mg/kg	4.2	10	No
METAL	Manganese	mg/kg	283	512	No
METAL	Mercury	mg/kg	0.20	0.33	No
METAL	Nickel	mg/kg	27	19	Yes
METAL	Silver	mg/kg	1.4	0.73	Yes
METAL	Uranium	mg/kg	23	3.2	Yes
METAL	Vanadium	mg/kg	27	85	No
METAL	Zinc	mg/kg	32	68	No
RAD_D	Cesium-137	pCi/g	1.51E+06	1.1	Yes
RAD_D	Cobalt-60	pCi/g	5.8	NA	NA
RAD_D	Plutonium-238	pCi/g	4.6	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	0.24	NA	NA
RAD_D	Plutonium-239/240	pCi/g	249	0.025	Yes
RAD_D	Potassium-40	pCi/g	15	17	No
RAD_D	Radium-226	pCi/g	1.1	0.82	Yes
RAD_D	Strontium-90	pCi/g	425,000	0.18	Yes
RAD_D	Technetium-99	pCi/g	132	NA	NA
RAD_D	Thorium-228	pCi/g	0.0087	1.3	No
RAD_D	Tritium	pCi/g	16	NA	NA

NA = not available.
RAD_D = decayed radiological.

Table C-30. Summary of Contaminants of Potential Concern for the 216-B-43, 216-B-44, 216-B-45, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs. (2 Pages)

Contaminant of Potential Concern	216-B-43		216-B-44		216-B-45		216-B-47		216-B-48		216-B-49		216-B-50	
	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP
Cyanide		X		X		X		X		X		X		
Nitrate		X		X		X		X		X				
Nitrite		X		X		X		X		X				
Sulfate		X		X				X		X				
Aluminum						X								
Antimony		X												
Cadmium		X			X	X	X	X						
Chromium		X						X						
Copper											X	X		
Lead				X	X	X		X		X		X		
Mercury						X				X		X		
Nickel		X		X		X		X		X		X		X
Selenium										X		X		
Silver	X	X	X	X	X	X					X	X		X
Thallium		X		X		X		X		X		X		
Vanadium						X								
Uranium		X		X	X	X		X		X		X		X
Cesium-134		X												
Cesium-137	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cobalt-60		X		X						X		X		X
Plutonium-238	X			X		X		X		X		X	X	X
Plutonium-239	X		X	X	X	X						X		X
Plutonium-239/240				X		X		X		X		X		X
Potassium-40							X	X						
Radium-226	X		X	X	X	X	X	X	X	X		X	X	X
Strontium-90	X		X	X	X	X	X	X	X	X	X	X	X	X
Technetium-99	X			X		X		X		X		X	X	X
Tritium				X		X		X		X		X		X
Benzoic acid			X	X										
Bis(2-ethyhexyl)phthalate	X	X	X	X	X	X	X	X	X	X	X	X		X
Butylbenzylphthalate		X		X		X								

Table C-30. Summary of Contaminants of Potential Concern for the 216-B-43, 216-B-44, 216-B-45, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs. (2 Pages)

Contaminant of Potential Concern	216-B-43		216-B-44		216-B-45		216-B-47		216-B-48		216-B-49		216-B-50	
	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP	Direct	GWP
Diethylphthalate		X			X	X								
Di-n-butylphthalate	X	X	X	X		X	X	X		X	X	X	X	X
Di-n-octylphthalate		X		X		X		X		X		X		
Dichlorordiphenyltrichloro-ethane		X						X	X					
Isophorone		X												
Pentachlorophenol	X	X					X	X						
Phenol			X	X										
2-butanone												X		
2-hexanone		X												
1,1,1-trichloroethane								X						
Acetone	X	X		X		X		X				X		X
Methylene chloride	X	X	X	X						X	X	X		X
Styrene		X												
Toluene		X	X	X	X	X	X	X	X	X				

GWP = groundwater protection.

Table C-31. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-43 Crib to WAC 173-340-745(5), Method C, Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
METAL	Silver	mg/kg	5	1	20%	1.2	17,500	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	5	1	20%	0.15	9,375	No
SVOA	Di-n-butylphthalate	mg/kg	5	1	20%	0.15	350,000	No
SVOA	Pentachlorophenol	mg/kg	5	1	20%	0.73	1,094	No
VOA	Acetone	mg/kg	5	1	20%	0.020	350,000	No
VOA	Methylene chloride	mg/kg	5	1	20%	0.0082	17,500	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.

Table C-32. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-44 Crib to WAC 173-340-745(5), Method C Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil CUL	Does Average Concentration Exceed WAC 173-340-745(5) Method C CUL?
METAL	Silver	mg/kg	6	1	17%	1.1	17,500	No
SVOA	2-chloronaphthalene	mg/kg	6	2	33%	0.14	NA	No
SVOA	Benzoic acid	mg/kg	4	1	25%	0.66	1.40E+07	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	1	17%	0.14	9,375	No
SVOA	Di-n-butylphthalate	mg/kg	6	1	17%	0.13	9,375	No
SVOA	Phenol	mg/kg	6	1	17%	0.17	350,000	No
VOA	Methylene chloride	mg/kg	6	1	17%	0.0093	17,500	No
VOA	Toluene	mg/kg	6	1	17%	0.0028	700,000	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
NA = not available.
SVOA = semi-volatile organic compound.
VOA = volatile organic compound.

Table C-33. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-45 Crib to WAC 173-340-745(5), Method C Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
METAL	Cadmium	mg/kg	7	3	43%	0.63	3,500	No
METAL	Lead	mg/kg	7	7	100%	7.3	--	No
METAL	Silver	mg/kg	7	2	29%	0.72	17,500	No
METAL	Thallium	mg/kg	7	1	14%	0.19	280	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	5	3	60%	0.096	9,375	No
SVOA	Diethylphthalate	mg/kg	5	1	20%	0.14	2.80E+06	No
VOA	Toluene	mg/kg	5	3	60%	0.0024	700,000	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.

Table C-34. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-47 Crib to WAC 173-340-745(5), Method C Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
METAL	Cadmium	mg/kg	6	2	33%	0.67	3,500	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.17	9,375	No
SVOA	Di-n-butylphthalate	mg/kg	6	1	17%	0.15	350,000	No
SVOA	Pentachlorophenol	mg/kg	6	2	33%	0.60	1,094	No
VOA	Toluene	mg/kg	6	1	17%	0.0023	700,000	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
SVOA = semi-volatile organic analyte.
TPH = total petroleum hydrocarbon.
VOA = volatile organic analyte.

Table C-35. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-48 Crib to WAC 173-340-745(5) Method C, Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.20	9,375	No
VOA	Toluene	mg/kg	6	2	33%	0.0021	700,000	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.

Table C-36. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-49 Crib to WAC 173-340-745(5), Method C Direct-Contact Cleanup Levels, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
METAL	Copper	mg/kg	6	6	100%	21	129,500	No
METAL	Silver	mg/kg	4	2	50%	1.2	17,500	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	6	2	33%	0.14	9,375	No
SVOA	Di-n-butylphthalate	mg/kg	6	2	33%	1.0	350,000	No
VOA	Acetone	mg/kg	6	2	33%	0.016	350,000	No
VOA	Methylene chloride	mg/kg	6	2	33%	0.010	17,500	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
RAD_D = decayed radiological.
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.

Table C-37. Comparison of True Mean Shallow Zone Soil Concentrations from 216-B-50 Crib to WAC 173-340-745(5), Method C Direct-Contact Risk-Based Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-745(5) Method C Soil Risk-Based Standard	Does Average Concentration Exceed WAC 173-340-745(5) Method C Risk-Based Standard?
SVOA	Di-n-butylphthalate	mg/kg	2	2	100%	0.44	350,000	No

Washington Administrative Code (WAC) 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
SVOA = semi-volatile organic analyte.

Table C-38. Comparison of True Mean Deep Zone Soil Concentrations from 216-B-43 Crib to WAC 173-340-747, Method B Groundwater Protection Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-747 Method B GWP Risk-Based Standard	Does True Mean Exceed WAC 173-340-747 Method B GWP Standard?
GENCH	Cyanide	mg/kg	18	5	28%	0.86	320	No
GENCH	Nitrate (as N)	mg/kg	3	3	100%	421	40	Yes
GENCH	Nitrite (as N)	mg/kg	3	3	100%	33	4.0	Yes
GENCH	Sulfate	mg/kg	3	3	100%	166	1,000	No
METAL	Antimony	mg/kg	18	1	6%	2.8	5.4	No
METAL	Cadmium	mg/kg	18	7	39%	0.61	0.69	No
METAL	Chromium	mg/kg	18	17	94%	14	18	No
METAL	Nickel	mg/kg	18	18	100%	12	130	No
METAL	Silver	mg/kg	18	6	33%	0.88	14	No
METAL	Thallium	mg/kg	18	1	6%	0.18	1.6	No
METAL	Uranium	mg/kg	20	9	45%	5.2	1.3	Yes
PEST	Dichlorodiphenyltrichloroethane	mg/kg	13	1	8%	0.014	3.5	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	13	5	38%	0.29	14	No
SVOA	Butylbenzylphthalate	mg/kg	14	2	14%	0.24	893	No
SVOA	Diethylphthalate	mg/kg	14	1	7%	0.17	72	No
SVOA	Di-n-butylphthalate	mg/kg	14	5	36%	0.37	11	No
SVOA	Di-n-octylphthalate	mg/kg	14	2	14%	0.15	532,000	No
SVOA	Isophorone	mg/kg	14	1	7%	0.17	0.45	No
SVOA	Pentachlorophenol	mg/kg	14	2	14%	0.70	0.012	Yes
VOA	2-hexanone	mg/kg	14	1	7%	0.0048	NA	NA
VOA	Acetone	mg/kg	14	3	21%	0.014	3.2	No
VOA	Methylene chloride	mg/kg	14	2	14%	0.0054	0.025	No
VOA	Styrene	mg/kg	14	1	7%	0.0025	0.033	No
VOA	Toluene	mg/kg	14	3	21%	0.0083	7.3	No

Washington Administrative Code (WAC) 173-340-747, "Deriving Soil Concentrations for Ground Water Protection."

GENCH = general chemical.
GWP = groundwater protection.
NA = not available.
PEST = pesticide.
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.

Table C-39. Comparison of True Mean Deep Zone Soil Concentrations from 216-B-44 Crib to WAC 173-340-747, Method B Groundwater Protection Standards, Human Health Risk Assessment.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	WAC 173-340-747 Method B GWP Standard	Does True Mean Exceed WAC 173-340-747 Method B GWP Standard?
GENCH	Complex cyanide	mg/kg	5	5	100%	33	320	No
GENCH	Cyanide	mg/kg	11	3	27%	1.9	320	No
GENCH	Free cyanide	mg/kg	5	5	100%	2.4	320	No
GENCH	Nitrate (as N)	mg/kg	6	6	100%	561	40	Yes
GENCH	Nitrite (as N)	mg/kg	6	4	67%	11	4.0	Yes
GENCH	Sulfate	mg/kg	6	6	100%	239	1,000	No
METAL	Lead	mg/kg	11	11	100%	4.9	3,000	No
METAL	Mercury	mg/kg	11	5	45%	0.054	2.1	No
METAL	Nickel	mg/kg	12	12	100%	19	130	No
METAL	Silver	mg/kg	11	1	9%	0.64	14	No
METAL	Thallium	mg/kg	11	4	36%	0.15	1.6	No
METAL	Uranium	mg/kg	12	7	58%	25	1.3	Yes
SVOA	2-chloronaphthalene	mg/kg	12	2	17%	0.16	NA	NA
SVOA	Benzoic acid	mg/kg	10	1	10%	0.77	257	No
SVOA	Bis(2-ethylhexyl) phthalate	mg/kg	12	4	33%	0.13	14	No
SVOA	Butylbenzylphthalate	mg/kg	12	1	8%	0.16	893	No
SVOA	Di-n-butylphthalate	mg/kg	12	3	25%	0.14	11	No
SVOA	Di-n-octylphthalate	mg/kg	12	4	33%	0.12	532,000	No
SVOA	Phenol	mg/kg	12	1	8%	0.17	44	No
VOA	Acetone	mg/kg	10	1	10%	0.0087	3.2	No
VOA	Methylene chloride	mg/kg	10	1	10%	0.0066	0.025	No
VOA	Toluene	mg/kg	10	1	10%	0.0027	7.3	No

Washington Administrative Code (WAC) 173-340-747, "Deriving Soil Concentrations for Ground Water Protection."

GENCH = general chemical.
GWP = groundwater protection.
NA = not available.
SVOA = semi-volatile organic analyte.
VOA = volatile organic analyte.